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BRACHIOPOD AND CONODONT FAUNAS FROM THE UPPERMOST WILLIAMS ISLAND FORMATION AND LOWER LONG RAPIDS FORMATION (MIDDLE AND UPPER DEVONIAN), MOOSE RIVER BASIN, NORTHERN ONTARIO

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BRACHIOPOD AND CONODONT FAUNAS FROM THE UPPERMOST WILLIAMS ISLAND FORMATION AND LOWER LONG RAPIDS FORMATION (MIDDLE AND UPPER DEVONIAN), MOOSE RIVER BASIN, NORTHERN ONTARIO

A.W. Norris, T.T. Uyeno, P. Sartenaer,
and P.G. Telford

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PREFACE

This report is a collaborative effort by participants from the Institut royal des Sciences naturelles de Belgique, the Ontario Geological Survey, and the Geological Survey of Canada. It describes and illustrates for the first time the rich brachiopod and conodont faunas present in the uppermost Williams Island Formation and lower Long Rapids Formation (Middle and Upper Devonian) exposed along the banks of the Abitibi River near Williams Island in the Moose River Basin of northern Ontario. These Devonian faunas from an intracratonic basin near the central part of the continent provide a link with those from basins in eastern, midcontinent, western, and arctic North America.

Although some of these brachiopod faunas had been mentioned in previous studies, their source beds, sequence, and precise relationships to one another were uncertain. A new stratigraphic section, in which several of these faunas occur in sequence, has resolved some of the uncertainties, and permits more reliable correlation between different areas.

Data from conodont and some brachiopod faunas enable precise dating of the enclosing strata. Zonations established both in the "deep" water *Palmatolepis* biofacies and the shallower water *Polygnathus* biofacies are applicable to these faunas. They allow international as well as regional correlation.

This work is part of an ongoing study of the detailed correlation of Devonian rocks in Canada, which provides an important framework for hydrocarbon and mineral exploration.

Elkanah A. Babcock
Assistant Deputy Minister
Geological Survey of Canada

PRÉFACE

Le présent rapport est le résultat d'un travail de collaboration entre des participants de l'Institut royal des Sciences naturelles de Belgique, de la Commission géologique de l'Ontario et de la Commission géologique du Canada. Il décrit et illustre pour la première fois les riches faunes de brachiopodes et de conodontes présentes dans la partie sommitale de la Formation de Williams Island et dans la partie inférieure de la Formation de Long Rapids (Dévonien moyen et Dévonien supérieur), qui affleurent le long de la rivière Abitibi près de l'île Williams (bassin de la rivière Moose dans le nord de l'Ontario). Ces faunes dévoniennes, qui proviennent d'un bassin intracratonique proche de la partie centrale du continent, établissent un lien entre les faunes des bassins de l'est, du milieu du continent, de l'ouest et des régions arctiques de l'Amérique du Nord.

Quelques-unes de ces faunes de brachiopodes avaient été mentionnées lors d'études antérieures, mais les couches dont elles proviennent, leur séquence et les relations précises qu'elles ont entre elles étaient incertaines. Une nouvelle coupe stratigraphique, dans laquelle plusieurs de ces faunes apparaissent en succession, a permis de lever quelques-unes de ces incertitudes et d'établir une corrélation plus fiable entre diverses régions.

Les données fournies par l'étude des conodontes et de quelques faunes de brachiopodes ont rendu possible une datation précise des strates qui les contiennent. La zonation observée dans le biofaciès «d'eau profonde» à *Palmatolepis* et dans le biofaciès d'eau moins profonde à *Polygnathus* est applicable à ces faunes. Ainsi, il a été possible d'établir des corrélations tant à l'échelle internationale que régionale.

Ces travaux font partie d'une étude en cours sur la corrélation détaillée des roches dévoniennes du Canada, qui constitue une source d'information fondamentale en exploration (hydrocarbures et minéraux).

Elkanah A. Babcock
Sous-ministre adjoint
Commission géologique du Canada

BRACHIOPOD AND CONODONT FAUNAS FROM THE UPPERMOST WILLIAMS ISLAND FORMATION AND LOWER LONG RAPIDS FORMATION (MIDDLE AND UPPER DEVONIAN), MOOSE RIVER BASIN, NORTHERN ONTARIO

Abstract

From a new section on the east bank of the Abitibi River, opposite the south end of Williams Island, conodonts are described from nine levels, and brachiopods and other macrofossils from three levels. Brachiopods from two nearby sections are also described.

Conodonts from the uppermost Williams Island Formation belong to the *Polygnathus* biofacies. The lowest fauna ranges from the *disparilis* (upper Givetian) to Lower *asymmetrica* (lower Frasnian) zones, whereas the remainder belong to the latter zone only. Early and late forms of *Ancyrodella rotundiloba* and an early form of *A. alata* in the uppermost level suggest reworking of faunas.

Brachiopods from the uppermost Williams Island Formation consist of 17 taxa, 11 of which are new. They are a mixture of Givetian and early Frasnian species, suggesting that they also have been reworked.

Conodonts of unassigned and *Palmatolepis* biofacies, and brachiopods and other fossils were obtained from the Long Rapids Formation. At the 8.2 m level, conodonts of early Frasnian age are associated with a species of calvinariid brachiopod, and the goniatite *Manticoceras* sp. cf. *M. sinuosum* (Hall). From the 8.9 to 9.5 m level, conodonts are assignable to Klapper's (1989a) Zone 11, or approximately *Ancyrognathus triangularis* Zone. From the 17.1 to 17.4 m level, conodonts of the Lower *gigas* Zone, middle Frasnian age, were obtained, associated with the brachiopod *Calvinaria* sp. cf. *C. ambigua* (Calvin).

The brachiopods *Hypothyridina*? sp. A and *Calvinaria* sp. A from the west bank of the Abitibi River opposite Williams Island are also described. The occurrence of *Hypothridina* prompted early workers to classify the enclosing beds as Williams Island Formation, based on a spurious correlation with the Tully Formation of New York. However, since *Calvinaria* sp. A resembles *C.* sp. cf. *C. ambigua* of the Lower *gigas* Zone, these strata belong to the Long Rapids Formation.

Résumé

Une nouvelle coupe située sur la rive orientale de la rivière Abitibi, en face de l'extrémité sud de l'île Williams, a permis de décrire des conodontes provenant de neuf niveaux, mais aussi des brachiopodes et d'autres macrofossiles provenant de trois niveaux. Des brachiopodes provenant de deux coupes situées non loin sont également décrits.

Les conodontes provenant de la partie sommitale de la Formation de Williams Island appartiennent au biofaciès à *Polygnathus*. La faune des strates les plus basses s'échelonne de la zone à *disparilis* (Givétien supérieur) à la zone inférieure à *asymmetrica* (Frasnien inférieur), tandis que le reste n'appartient qu'à la seconde zone. La présence des formes précoces et tardives d'*Ancyrodella rotundiloba* et d'une forme précoce d'*A. Alata* dans le niveau sommital suggèrent un remaniement des faunes.

Les brachiopodes provenant de la partie sommitale de la Formation de Williams Island font partie de 17 taxons, dont 11 sont nouveaux. Ils représentent un mélange d'espèces datant du Givétien et du Frasnien précoce, ce qui suggère qu'ils ont également subi un remaniement.

Des conodontes (d'un biofaciès non désigné et du biofaciès à *Palmatolepis*), des brachiopodes et d'autres fossiles ont été échantillonnés dans la Formation de Long Rapids. Au niveau 8,2 m, les conodontes datant du Frasnien précoce sont associés à une espèce de brachiopodes de la famille des Calvinariidés et au goniatite *Manticoceras* sp. cf. *M. sinuosum* (Hall). Du niveau 8,9 m au niveau 9,5 m, les conodontes peuvent être placés dans la Zone 11 définie par Klapper (1989a), ou approximativement dans la Zone à *Ancyrognathus triangularis*. Entre les niveaux 17,1 m et 17,4 m, des conodontes de la Zone inférieure à *gigas*, datant du Frasnien moyen et associés au brachiopode *Calvinaria* sp. cf. *C. ambigua* (Calvin), ont été récoltés.

Ont également été décrits les brachiopodes *Hypothyridina*? sp. A. et *Calvinaria* sp. A. provenant de la rive occidentale de la rivière Abitibi, face à l'île Williams. La présence d'*Hypothyridina* a poussé les premiers chercheurs à classer les strates qui contiennent ces brachiopodes dans la Formation de Williams Island, conformément à une corrélation erronée avec la Formation de Tully (New York). Toutefois, *Calvinaria* sp. A ressemble à *C.* sp. cf. *C. ambigua* de la Zone inférieure à *gigas* et s'observe dans la Formation de Long Rapids.

Summary

The brachiopods and conodonts described and illustrated in this report are from the uppermost Williams Island Formation and lower Long Rapids Formation outcropping on Abitibi River in the vicinity of Williams Island in the southeastern part of the Moose River Basin of northern Ontario. These formations constitute the upper two rock units of the Devonian succession of the Hudson Platform.

The Williams Island Formation is defined as the beds disconformably overlying limestone of the Murray Island Formation, and disconformably underlying shale of the Long Rapids Formation. Throughout the Moose River Basin, the Williams Island Formation consists of a lower, recessive shale member, and an upper, resistant carbonate member. To this is now added an uppermost, thin member of green "clay-shale" containing abundant brachiopods.

In the Moose River Basin, the lower member varies in thickness from 36 to 47 m, and the upper member from 33 to 45 m. The new uppermost member is between 1.3 and 4 m thick.

The thin, uppermost member of the formation is exposed at the base of a recently studied section on the east bank of Abitibi River opposite the south end of Williams Island. There, the unit consists of 1.3 m of green "clay-shale" containing three, thin, concretionary, calcareous layers. Brachiopods are exceedingly abundant, especially at the base of the unit.

Although some workers consider this uppermost member to be a part of the overlying Long Rapids Formation, it is here classified as part of the Williams Island Formation for the following reasons: 1) the original definition of the Long Rapids Formation applied to a grey to black shale; 2) the green "clay-shale" lithology is more common in the Williams Island Formation; 3) the unit is separated from underlying and overlying beds by depositional breaks; 4) all of the early workers considered the brachiopod fauna from this unit to be a part of the Williams Island Formation; 5) the brachiopods exhibit reworking and mixing of forms from different, older levels of Givetian age; and 6) the brachiopods are distinctly different from those in the succeeding Long Rapids Formation.

The name Long Rapids Formation applies to an Upper Devonian unit consisting mainly of grey to black shale exposed along the Abitibi River in the vicinity of Long Rapids. Beds of the formation disconformably overlie the uppermost member of the Williams Island Formation and are unconformably overlain by beds of continental sand, clay, and lignite of Mesozoic age in the Moose River Basin.

The main exposures of the Long Rapids Formation are along the Abitibi River where they outcrop discontinuously over distances of 2.4 km above and 3.2 km below Williams Island.

Recorded thicknesses of the formation range from 12 to 87 m. In the new section measured on the east bank of the Abitibi River opposite the south end of Williams Island, 35 m are exposed.

The Long Rapids Formation consists mainly of dark, petroliferous shale, with some interbedded green-grey, variably calcareous claystone, minor thin beds of limestone, and scattered, thin, concretionary, iron-rich carbonate layers. The base of the formation is here selected at the first appearance of dark shale, which complies with the original definition of the formation.

From the recently studied section on the east bank of Abitibi River opposite the south end of Williams Island, conodont samples were taken from nine levels, and brachiopods and other megafossils from three levels. These sequentially collected fossils have proven to be exceedingly useful in establishing the relationships of the numerous previously recorded scattered brachiopod collections from the area. In addition, important brachiopods are described from two nearby sections in the Williams Island area.

Conodonts from the 1.3 m thick, green "clay-shale" unit here assigned to the Williams Island Formation were studied from three samples. Conodonts from the lowest level, 0.7 m above the base of the section (GSC loc. C-136487), span the *disparilis* Zone to Zone 3 of Klapper (1989a), the latter falling within the Lower *asymmetrica* Zone of Ziegler's (1962, 1971) standard zonation. This interval is of late Givetian to early Frasnian age. The second sample is from the matrices of a rich brachiopod collection listed below, collected over the 1.3 m thick "clay-shale" interval, although most of the collections are from the lower part of this unit (GSC loc. C-136485). Its sparse faunule suggests an age within the Lower *asymmetrica* Zone, or approximately Zone 2 or 3 of Klapper (1989a). The highest sample (locality Ab-4; GSC loc. C-136487), from the top 0.3 m of the green "clay-shale", yielded mixed conodonts of Zones 1 and 2 of Klapper (1989a), of earliest Late Devonian age. The conodonts from all three samples belong to the *Polygnathus* biofacies.

The highest part of the Williams Island Formation correlates with the Christina and Moberly members of the Waterways Formation of northeastern Alberta, and with the Penn Yann Shale and Genundewa Limestone members of the Genesee Formation of western New York.

From the lowest brachiopod collection (locality Ab-"11"; GSC loc. C-136485) in the uppermost part of the Williams Island Formation, 17 brachiopod taxa, 11 of which are new, are described and illustrated. The fauna includes *Schizophoria* sp. cf. *S. athabaskensis* Warren, *Strophodonta* (*Strophodonta*) *abitibiensis* Norris n. sp., *Nervostrophia ralla* Norris n. sp., *Eostrophalosia parksi* Norris n. sp., *Ladogioides pusilla* Sartenaer n. sp., *Leiorhynchus quadracostatus alces* Sartenaer n. subsp., *Atryparia rubra* Cooper and Dutro, *Desquamatia* (*Independatrypa*) *exila* Norris n. sp., *D.* (*Independatrypa*) sp. A, *D.* (*Independatrypa*) sp. B, *Spinatrypa* (*Spinatrypa*) sp. A, *Spinatrypa* (*Spinatrypa*) *tribulosa* Norris n. sp., *Emanuella martisoni* Norris n. sp., *Ladjia*? *plicata* Norris n. sp., *Cyrtina* sp. cf. *C. triquetra* (Hall), *Tecnocyrtina bicostata* Norris n. sp., and *Mucrospirifer williamsi* Norris n. sp.

These brachiopods display near affinities or identities with forms from the Appohimchi and Michigan Basin–Hudson Bay Lowland Provinces of the Eastern Americas Realm, and the Cordilleran Province of the Old World Realm. Collectively, the related comparative forms range in age from the conodont Lower *varcus* Subzone to Middle *asymmetrica* Zone, suggesting that some of the brachiopods in the uppermost Williams Island Formation have been reworked from lower levels of the formation that are now missing by erosion. The youngest diagnostic brachiopods, like the conodonts, are aligned with the Lower *asymmetrica* Zone of early Frasnian age. This assemblage of brachiopods is obviously the same as that reported by Savage and Van Tuyl (1919, p. 373) from their unit 11 immediately below black shale of the Long Rapids Formation.

The overlying Long Rapids Formation was sampled at six levels for conodonts. The lowest of these, from 6.1 to 6.4 m above base of formation (locality Ab-5; GSC loc. C-136488) yielded only long-ranging taxa. Conodonts from the next higher level, at 6.9 to 7.0 m above the base of the formation (locality Ab-6; GSC loc. 100799), can be assigned, in terms of Klapper's (1989a) zonations, to the upper part of Zone 10 and the lower part of Zone 11, and Zone 4b of Klapper and Lane (1989), of early Frasnian age. This correlates with the upper Perdrix Formation of the southern Rocky Mountains (Klapper and Lane, 1989). The next two levels, from 7.6 to 8.2 m above the base of the formation (locality Ab-8, GSC loc. C-136490; and locality Ab-9, GSC loc. C-136491) belong to Zone 11 (Klapper, 1989a) or Zone 5b (Klapper and Lane, 1989), which is approximately the *Ancyrognathus triangularis* Zone of Ziegler (1962, 1971). Zone 5b spans the Perdrix–Mount Hawk formational boundary in Alberta. The highest level, at 16.0 to 16.1 m above the base of the formation (locality Ab-12; GSC loc. C-136493), yielded conodonts of Klapper's (1989a) Zone 12, or Faunal Interval 7 of Klapper and Lane (1989) and equivalent to Zieger's Lower *gigas* Zone of the standard zonation, of middle Frasnian age. Faunal Interval 7 occurs in the upper part of the Mount Hawk Formation in the southern Rocky Mountains, and is correlated with faunas from the upper Fort Simpson Shale and the Jean-Marie Member of the Redknife Formation in southwestern District of Mackenzie (Klapper and Lane, 1989). The Long Rapids Formation conodonts belong to an unassigned biofacies and the *Palmatolepis* biofacies.

From locality Ab-6 (GSC loc. 100799) sparse remains of a species of calvinariid brachiopod are associated with numerous goniatite specimens of *Manticoceras* sp. cf. *M. sinuosum* (Hall). These occur in a thin, nodular limestone bed within the Long Rapids Formation, 8.2 to 8.3 m above the base of the section. These goniatites are obviously the same as those previously described by Foerste (1928) and Miller (1938) from the Williams Island area. As mentioned above, the brachiopods and goniatites of locality Ab-6 (GSC loc. 100799) are associated with conodonts of early Frasnian age.

From the third brachiopod level in the section (locality Ab-12; GSC loc. C-136493) three specimens of *Calvinaria* sp. cf. *C. ambigua* were collected from a thin limestone bed within the Long Rapids Formation, 9.1 m above the goniatite bed and 17.3 to 17.4 m above the base of the section. The occurrence of this brachiopod suggests a correlation with the Independence Shale of Iowa.

From a fourth level (GSC loc. 6570), two brachiopods, *Hypothyridina*? sp. A and *Calvinaria* sp. A, are described, which were collected by Williams (1920a, b) in 1919 from a 0.61 m bed of green, pyritic limestone outcropping on the west bank of Abitibi River opposite Williams Island. The presence of *Hypothyridina* prompted Kindle (1924) and later workers to consider the containing bed as the uppermost part of the Williams Island Formation, which was correlated with the Tully Formation of New York. *Calvinaria* sp. A is closely related to *C. ambigua* (Calvin), suggesting that the containing bed is part of the Long Rapids Formation and probably equivalent to the level represented by locality Ab-12 (GSC loc. C-136493).

Sommaire

Les brachiopodes et les conodontes décrits et illustrés dans le présent rapport proviennent de la partie sommitale de la Formation de Williams Island et de la partie inférieure de la Formation de Long Rapids, qui affleurent le long de la rivière Abitibi près de l'île Williams (partie sud-est du bassin de la rivière Moose dans le nord de l'Ontario). Ces formations constituent les deux unités lithostratigraphiques supérieures de la succession dévonienne observée dans la région de la Plate-forme d'Hudson.

La Formation de Williams Island est définie comme constituant les lits qui recouvrent en disconformité le calcaire de la Formation de Murray Island et qui sont recouverts en disconformité par le shale de la Formation de Long Rapids. Dans l'ensemble du bassin de la rivière Moose, la Formation de Williams Island se compose d'un membre inférieur de shale peu résistant et d'un membre supérieur de roches carbonatées résistantes. S'ajoute maintenant un mince membre sommital de «shale argileux» vert aux brachiopodes abondants.

Dans le bassin de la rivière Moose, l'épaisseur du membre inférieur varie de 36 à 47 m et celle du membre supérieur de 33 à 45 m. Quant au membre sommital susmentionné, il mesure entre 1,3 m et 4 m d'épaisseur.

Le mince membre sommital de la formation affleure à la base d'une coupe récemment étudiée sur la rive orientale de la rivière Abitibi, face à l'extrémité sud de l'île Williams. À cet endroit, l'unité se compose de 1,3 m de «shale argileux» contenant trois minces couches calcareuses à concrétions. Les brachiopodes sont extrêmement abondants, surtout à la base de l'unité.

Dans le présent document, le membre sommital est associé à la Formation de Williams Island, bien que quelques chercheurs le placent dans la Formation de Long Rapids immédiatement sus-jacente. Les raisons qui expliquent ce choix sont les suivantes : 1) la définition initiale de la Formation de Long Rapids s'appliquait à un shale gris à noir; 2) le «shale argileux» vert est plus

fréquent dans la Formation de Williams Island; 3) l'unité soit séparée des lits sous-jacents et sus-jacents par des lacunes stratigraphiques; 4) les premiers chercheurs ont tous considéré la faune de brachiopodes de cette unité comme constituant une partie de la Formation de Williams Island; 5) les brachiopodes montrent tous deux un remaniement et un mélange de formes provenant de niveaux différents, plus anciens (d'âge givétien); et 6) les brachiopodes et les conodontes sont nettement différents de ceux que l'on rencontre dans la Formation de Long Rapids immédiatement sus-jacente.

L'appellation «Formation de Long Rapids» désigne une unité du Dévonien supérieur se composant principalement d'un shale gris à noir, qui affleure le long de la rivière Abitibi à proximité de Long Rapids. Les lits de la formation recouvrent en disconformité le membre sommital de la Formation de Williams Island et sont recouverts en discordance par des lits mésozoïques de sable, d'argile et de lignite continentaux du bassin de la rivière Moose.

Les principaux affleurements de la Formation de Long Rapids s'observent en bordure de la rivière Abitibi; ils sont discontinus et s'observent sur des distances de 2,4 km en amont et 3,2 km en aval de l'île Williams.

Selon les observations, l'épaisseur de la formation se situe entre 12 m et 87 m. À l'emplacement de la nouvelle coupe sur la rive orientale de la rivière Abitibi, en face de l'extrémité sud de l'île Williams, l'épaisseur est de 35 m.

La Formation de Long Rapids se compose principalement de shale pétrolifère de couleur foncée, avec quelques interlits de claystone gris vert plus ou moins calcareux, de minces lits de calcaires (secondaires) et de minces couches carbonatées riches en fer, éparses et à concrétions. La base de la formation est établie ici à la première apparition du shale foncé, ce qui concorde avec la définition initiale de la formation.

Au site de la coupe récemment étudiée sur la rive orientale de la rivière Abitibi, face à l'extrémité sud de l'île Williams, on a échantillonné des conodontes dans neuf niveaux et des brachiopodes et autres mégafossiles dans trois niveaux. Ces fossiles prélevés de façon séquentielle se sont avérés extrêmement utiles pour faire le lien entre les nombreuses collections éparses de brachiopodes de ce secteur, déjà répertoriées. D'importants brachiopodes provenant de deux coupes situées non loin dans la région de l'île Williams ont également été décrits.

Les conodontes de l'unité de «shale argileux» vert de 1,3 m d'épaisseur, attribuée ici à la Formation de Williams Island, ont été étudiés à partir de trois échantillons. Les conodontes du niveau le plus bas, observés à 0,7 m au-dessus de la base de la coupe (loc. C-136487 CGC), couvrent l'intervalle de la Zone à *disparilis* à la Zone 3 de Klapper (1989a), cette dernière étant située dans la Zone inférieure à *asymmetrica* selon la zonation type de Ziegler (1962, 1971). Cet intervalle s'échelonne du Givétien tardif au Frasnien précoce. Le second échantillon a été prélevé des matrices d'une riche collection de brachiopodes (énumérés ci-dessous), échantillonnés dans l'intervalle de «shale argileux» de 1,3 m d'épaisseur; il est cependant à noter que la plupart des collections proviennent de la partie inférieure de cette unité (loc. C-136485 CGC). L'examen de sa faunule dispersée suggère un âge correspondant à la Zone inférieure à *asymmetrica*, ou approximativement à la Zone 2 ou 3 de Klapper (1989a). L'échantillon provenant du niveau le plus élevé (localité Ab-4; loc. C-136487 CGC), récolté dans les 0,3 m supérieurs du «shale argileux», contient divers conodontes des Zones 1 et 2 de Klapper (1989a) qui datent du tout début du Dévonien tardif. Les conodontes des trois échantillons appartiennent au biofaciès à *Polygnathus*.

La partie sommitale de la Formation de Williams Island correspond aux membres de Christina et de Moberly de la Formation de Waterways (nord-est de l'Alberta), de même qu'aux membres du Shale de Penn Yann et du Calcaire de Genundewa de la Formation de Genesee (partie ouest de l'État de New York).

La collection de brachiopodes provenant des niveaux les plus bas (localité Ab-"11"; loc. C-136485 CGC) de la partie sommitale de la Formation de Williams Island comprend 17 taxons de brachiopodes, dont 11 sont nouveaux; ils ont tous été décrits et illustrés. La faune inclut *Schizophoria* sp. cf. *S. athabaskensis* Warren, *Strophodonta* (*Strophodonta*) *abitibiensis* Norris n. sp., *Nervostrophia ralla* Norris n. sp., *Eostrophalosia parksi* Norris n. sp., *Ladogioides pusilla* Sartenaer n. sp., *Leiorhynchus quadracostatus alces* Sartenaer n. subsp., *Atryparia rubra* Cooper et Dutro, *Desquamatia* (*Independatrypa*) *exila* Norris n. sp., *D.* (*Independatrypa*) sp. A, *D.* (*Independatrypa*) sp. B, *Spinatrypa* (*Spinatrypa*) sp. A., *Spinatrypa* (*Spinatrypa*) *tribulosa* Norris n. sp., *Emanuella martisoni* Norris n. sp., *Ladjia*? *plicata* Norris n. sp., *Cyrtina* sp. cf. *C. triquetra* (Hall), *Tecnocyrtina bicostata* Norris n. sp. ainsi que *Mucrospirifer williamsi* Norris n. sp.

Ces brachiopodes présentent de fortes affinités (ou sont identiques) avec des formes venant du Domaine est-américain (Province d'Appohimchi ainsi que Province du bassin du Michigan et des basses terres de la baie d'Hudson) et du Domaine du Vieux monde (Province cordillérienne). Dans l'ensemble, les formes comparatives apparentées se situent chronologiquement dans l'intervalle de la Sous-zone inférieure à *varcus* (conodonte) à la Zone moyenne à *asymmetrica*, ce qui semble indiquer que quelques-uns des brachiopodes de la partie sommitale de la Formation de Williams Island ont été remaniés à partir de niveaux inférieurs de la formation que l'érosion a fait disparaître. Les plus jeunes brachiopodes caractéristiques, comme les conodontes, sont alignés avec la Zone inférieure à *asymmetrica* qui date du Frasnien précoce. Cet assemblage de brachiopodes est de toute évidence le même que celui signalé par Savage et Van Tuyl (1919, p. 373) dans l'unité 11, qui se trouve immédiatement au-dessous du shale noir de la Formation de Long Rapids.

Des conodontes ont été échantillonnés dans six niveaux de la Formation de Long Rapids sus-jacente. Le plus bas de ces niveaux, entre 6,1 et 6,4 m au-dessus de la base de la formation (localité Ab-5; loc. C-136488 CGC), ne contenait que des taxons à grande extension stratigraphique. Les conodontes du niveau immédiatement supérieur, entre 8,2 et 8,3 m au-dessus de la base de la coupe (localité Ab-6; loc. 100799 CGC), peuvent être associés à la partie supérieure de la Zone 10 et à la partie inférieure de la Zone 11 (selon Klapper, 1989a), mais aussi à la Zone 4b du Frasnien précoce (selon Klapper et Lane, 1989). Ces strates peuvent être corrélées avec la partie supérieure de la Formation de Perdrix, située dans les Rocheuses méridionales (Klapper et Lane, 1989). Les deux niveaux suivants, entre 7,6 m et 8,2 m au-dessus de la base de la formation (localité Ab-8, loc. C-136490 CGC; et localité Ab-9, loc. C-136491 CGC), appartiennent à la Zone 11 (Klapper, 1989a) ou à la Zone 5b (Klapper et Lane, 1989), qui correspond approximativement à la Zone à *Ancyrognathus triangularis* de Ziegler (1962, 1971). La Zone 5b englobe la limite entre les formations de Perdrix et de Mount Hawk en Alberta. Au niveau le plus élevé, situé entre 16,0 m et 16,1 m au-dessus de la base de la formation (localité Ab-12; loc. C-136493 CGC), ont été rencontrés des conodontes de la Zone 12 de Klapper (1989a) ou de l'intervalle faunique 7 de Klapper et Lane (1989) qui, selon la zonation type de Ziegler, correspondent à la Zone inférieure à *gigas* du Frasnien moyen. L'intervalle faunique 7 se trouve dans la partie supérieure de la Formation de Mount Hawk, située dans les Rocheuses méridionales, et a été corrélé avec les faunes venant de la partie supérieure du Shale de Fort Simpson ainsi que du Membre de Jean-Marie appartenant à la Formation de Redknife, observée dans la partie sud-ouest du district de Mackenzie (Klapper et Lane, 1989). Les conodontes de la Formation de Long Rapids appartiennent à un biofaciès non désigné et au biofaciès à *Palmatolepis*.

Dans la localité Ab-6 (loc. 100799 CGC), les restes épars d'un brachiopode de la famille des Calvinariidés sont associés à de nombreux spécimens de goniatites appartenant à l'espèce *Manticoceras* sp. cf. *M. sinuosum* (Hall). Ceux-ci apparaissent dans un mince lit de calcaire noduleux à l'intérieur de la Formation de Long Rapids, dans l'intervalle compris entre 8,2 m et 8,3 m au-dessus de la base de la coupe. Ces goniatites sont de toute évidence les mêmes que celles antérieurement décrites par Foerste (1928) et Miller (1938) dans la région de l'île Williams. Les brachiopodes et les goniatites de la localité Ab-6 (loc. 100799 CGC) sont associés à des conodontes du Frasnien précoce.

Au troisième niveau à brachiopodes de la coupe (localité Ab-12; loc. C-136493 CGC), trois spécimens de *Calvinaria* sp. cf. *C. ambigua* ont été échantillonnés dans un mince lit de calcaire situé à l'intérieur de la Formation de Long Rapids, 9,1 m au-dessus du lit à goniatites et entre 17,3 m et 17,4 m au-dessus de la base de la coupe. La présence de ce brachiopode suggère une corrélation avec le Shale d'Independance de l'Iowa.

Deux brachiopodes provenant d'un quatrième niveau (loc. 6570 CGC), *Hypothyridina*? sp. A. et *Calvinaria* sp. A., ont de plus été décrits; ils avaient été échantillonnés en 1919 par Williams (1920a, b) dans un lit de calcaire pyriteux vert de 0,61 m d'épaisseur, affleurant sur la rive occidentale de la rivière Abitibi, face à l'île Williams. La présence d'*Hypothyridina* a poussé Kindle (1924), et plus tard d'autres chercheurs, à considérer la couche qui contient ces brachiopodes comme la partie sommitale de la Formation de Williams Island, correspondant à la Formation de Tully (New York). *Calvinaria* sp. A. est étroitement apparentée à *C. ambigua* (Calvin), ce qui semble indiquer que la couche encaissante fasse partie de la Formation de Long Rapids et soit probablement équivalente au niveau que représente la localité Ab-12 (loc. C-136493 CGC).

INTRODUCTION

Location

The fossils described in this report are from the uppermost Williams Island Formation and lower Long Rapids Formation exposed on the banks of the Abitibi River in the vicinity of Williams Island. This island is located in the southern part of the Moose River Basin in northern Ontario at approximately latitude 50°24′10″N, longitude 81°34′20″W (Moose River map sheet, NTS 42 I (Figs. 1-3). The Ontario Northland Railway line connecting Cochrane in the south with Moosonee in the north, a distance of 186 mi. (297.6 km), crosses the Hudson Bay Lowlands 2.1 km west of Williams Island. Along the railway line, Williams Island is opposite a position approximately 22 km north of the Coral Rapids Post Office.

Previous paleontological work

The first mention of fossils from beds now known to include the uppermost part of the Williams Island Formation was that by Savage and Van Tuyl (1919, p. 373), who investigated the area in 1916 and who recorded the following forms:

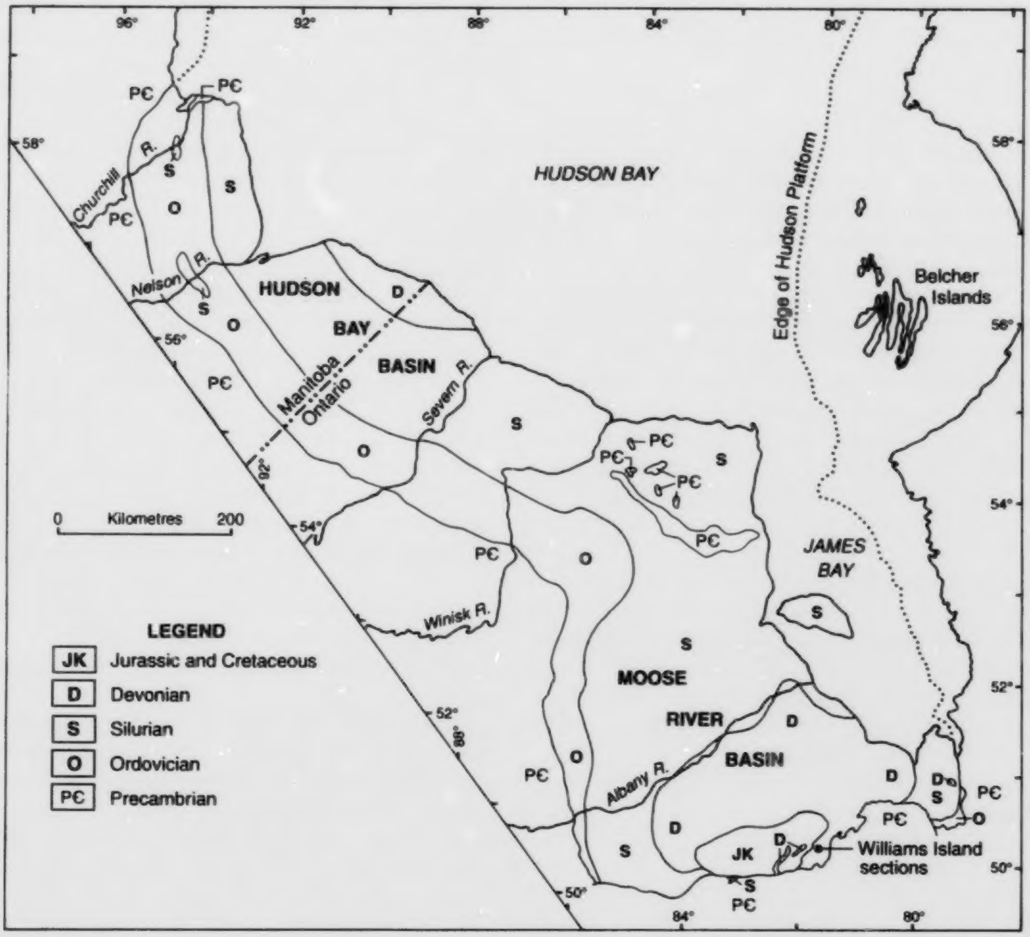
"*Leptostrophia* cf. *perplana*
Schuchertella chemungensis var.
Productella cf. *productoides*
Schizophoria iowensis
Leiorhynchus near *globuliformis*
Leiorhynchus near *kelloggi*
Leiorhynchus aff. *mesacostalis*
Atrypa missouriensis
Atrypa reticularis
Cyrtina hamiltonensis var.
Cyrtina hamiltonensis
Spirifer subvaricosus
Delthyris sculptilis
Reticularia aff. *laevis*
Athyris fultonensis"

These fossils are from beds designated as unit 11 (8 ft./2.44 m thick), and described as calcareous shale alternating with irregular nodular limestone layers, each varying from 4 to 10 in. (1.57 to 3.94 cm) thick. Beds of unit 11 were recorded from along the west bank of the Abitibi River, where they immediately underlie black shale of the Long Rapids Formation and where a syncline crosses the river near the middle of Long Rapids. From what is now known of the distribution of outcrops in the area (Fritz et al., 1957, Pl. 1) the fossils were probably collected from beds exposed about 0.34 mi. (0.54 km) north of the north end of Williams Island. The leiorhynchids in the above collection of Savage and Van Tuyl (1919) were examined later by P. Sartenaer, who concluded that a single species is represented by a form closely related to *Leiorhynchus quadracostatus* (Vanuxem) (Sanford and Norris, 1975, p. 68, 70, 85).

Four fragments of a specimen of *Manticoceras*, indicating an age younger than that suggested by the brachiopods, were collected also, but not mentioned, by Savage and Van Tuyl (1919) from their unit 11, and these fragments were later described and illustrated by Foerste (1928, p. 104-106, Pl. 21, figs. 2A-E, Pl. 28, figs. 3A-C), and Miller (1938, p. 115, 116, Pl. 22, figs. 10-13). On the basis of the presently known distribution of brachiopods and ammonoids in the Williams Island section, it is apparent that unit 11 of Savage and Van Tuyl (1919) includes beds of both the Williams Island and Long Rapids formations.

Following well travelled canoe routes, Williams (1920a, b) in 1919 investigated the geology of the Mattagami, Moose, and Abitibi rivers. He recorded (Williams, 1920a, p. 8, 1920b, p. 26), in ascending sequence, the following section from along the west bank of the Abitibi River opposite a large limestone island (later named Williams Island) near the foot of rapids (actually about the middle of Long Rapids): 20 ft. (6.10 m) of heavy unevenly bedded limestone, of Onondaga age; about 6 or 7 ft. (1.83 or 2.13 m) of green argillaceous shale; about 8 or 10 ft. (2.44 or 3.05 m) of brown to black shale; and a 2 ft. (0.61 m) thick bed of green limestone with shale partings carrying considerable pyrite. From the uppermost green limestone bed, Williams (1920a, b) reported "*Hypothyris cuboides* (Sowerby)" suggesting a Tully age, and "*Leiorhynchus*(?) sp." In addition, from a small outcrop of bluish shale containing nodular limestone on Mattagami River, about 4 mi. (6.4 km) above Pike Creek, Williams (1920a, p. 9, 1920b, p. 26, 27) reported *Pugnax pugnus* (Martin), a form he considered characteristic of the Portage phase of the Ithaca fauna of New York State.

In 1923, Kindle investigated a part of the Moose River Basin along the Missinaibi, Moose, and Abitibi rivers, and a 30 mi. (48.3 km) stretch of the James Bay coastline northwest of Moosonee. Kindle (1924, p. 34, 35) introduced the names "Williams Island", for the large island in the Abitibi River near the lower end of Long Rapids, and "Williams Island Limestone", for the beds exposed on the island and adjacent banks of the river. Kindle (1924, p. 35) was the first worker to present a measured section of the beds exposed on the



96°
92°
88°
84°
80°
58°
56°
54°
52°
50°
PЄ
S
O
D
JK
Churchill R.
Nelson R.
HUDSON BAY
HUDSON BAY BASIN
Manitoba
Ontario
Severn R.
Winisk R.
Albany R.
MOOSE RIVER BASIN
JAMES BAY
Edge of Hudson Platform
Belcher Islands
Williams Island sections
0 Kilometres 200
LEGEND
JK Jurassic and Cretaceous
D Devonian
S Silurian
O Ordovician
PЄ Precambrian

Figure 1. Map showing distribution of Phanerozoic rocks in the Hudson Bay Lowlands and locations of sections near Williams Island.

island. In commenting on the brachiopod fossils recorded by Savage and Van Tuyl (1919) and Williams (1920a, b) from the Williams Island area, Kindle (1924, p. 35) pointed out the Hamilton and post-Hamilton affinities of these fossils.

Dyer (1928) summarized all previous information on the stratigraphy, paleontology, structural geology, and mineral deposits of the Moose River Basin, including a map showing all known outcrops. His report was augmented by new observations made on exploratory trips during the summers of 1927 and 1928. From the Williams Island Formation, Dyer (1928, p. 27) reported for the first time the presence of "*Leiorhynchus* cf. *quadricostata*". From an outcrop of the Long Rapids Formation on the east side of the Mattagami River, 4 mi. (6.4 km) above Grand Rapids, Dyer (1928, p. 29) reported "*Leiorhynchus* cf. *kelloggi*". This is the same locality from which Williams (1920a, b) had previously reported "*Pugnax pugnus*".

Dyer (1931, 1932) described the succession of rocks penetrated by the Ontario Department of Mines drillhole A located in the Onakawana lignite field (52°26′12″N, 81°34′30″W), which was the first well to reach the Precambrian basement in the Moose River Basin. In this well, the Williams Island Formation was 301 ft. (91.8 m) thick, and the Long Rapids Formation 285 ft. (86.9 m) thick. New paleontological information in one of these reports (Dyer, 1931, p. 90) included a composite list of fossils identified by E.M. Kindle from the lower and middle parts of the Long Rapids Formation, as follows:

"*Protosylvania huronensis* (Dawson)
crinoid stems
Lingula ligea Hall
Lingula n. sp.
Leiorhynchus cf. *laura* Billings
Chonetes cf. *lepida* Hall
Ambocoelia umbonata (Conrad)
Styliolina fissurella Hall
Polygnathellus cf. *curvatus* Ulrich and Bassler"

The comprehensive report of Martison (1953, p. 1–58) on the James Bay Lowland summarized all previous geological work, and added new information based on canoe and air reconnaissance surveys of the area made in 1946. New information on the Williams Island Formation provided by Martison (1953, p. 44) included a list of fossils collected by Dyer (1928, p. 27), presumably from the west side of the island. These fossils were identified by Wilson (1953, p. 75) as follows:

"*Spirorbis arkonensis* Nicholson
Spirorbis sp.
Favosites hamiltoniae Hall
Ceratopora sp. near *C. jacksoni* Grabau
undet. bryozoa
Chonetes sp. D
Chonetes sp. E
Gypidula laeviuscula Hall
Gypidula sp. A
Gypidula sp. B
Spirifer, fragment
spiriferoid brachiopod
Atrypa spinosa Hall
Atrypa sp. E
Athyris fultonensis (Swallow)
Elytha fimbriata var.
Cryptonella sp."

Wilson commented that several of these species ranged in age from the Hamilton to early Portage.

Wilson (1953, p. 75) re-examined the fossils from the core of the Long Rapids Formation from Onakawana drillhole A (the top and bottom of the formation are at 250 ft./76.2 m and 535 ft./163 m respectively) and provided the following identifications:

Depth ft./m	
410/125	*Polygnathellus* sp. *Lingula* sp.
450/137.2	*Leiorhynchus* sp. B
499/152.1	*Protosylvania* sp., large *Lingula* sp. A
501/152.7	*Lingula* sp. A *Productella* sp. A cf. *Leiorhynchus* sp.
505/153.9	*Chonetes* sp. near *C. lepidus* Hall *Productella* sp. A *Ambocoelia umbonata* (Conrad)
517/157.6	*Chonetes* sp. near *C. lepidus* Hall *Productella* sp.
522/159.1	*Styliolina fissurella* (Hall) *Lingula* sp. A *Leiorhynchus* sp. B *Leiorhynchus* sp. C *Ambocoelia umbonata* (Conrad)

Wilson (1953, p. 75) concluded that the above fauna indicated a Hamilton or early Portage age. She (p. 74) also re-examined the fossils collected in 1919 by Williams (1920a, b) from the Williams Island and Long Rapids formations outcropping along the Abitibi River in the vicinity of Williams Island. Her identifications, with revisions and comments by the writer (AWN) in brackets, are as follows:

GSC locality 6568, lower part of Long Rapids, 4 mi. (6.4 km) below series of small islands, Abitibi River, Long Rapids Formation:

Protosylvania huronensis Dawson [*Tasmanites huronensis* (Dawson)]

GSC locality 6570, two feet (0.61 m) of green limestone (considered by previous workers to be a part of the Williams Island Formation), a short distance above (outcrop of) Huron Shale (Long Rapids Formation), just below lowest island (Williams Island) series at foot of Long Rapids:

Chonetes sp. C [*Strophodonta* (*Strophodonta*) sp.]
Leiorhynchus sp. A (*Calvinaria* sp. A; described in this report)
Hypothyridina sp. (*Hypthyridina*? sp. A; described in this report)
rhynchonellid brachiopod
(tentaculitid)
(echinoderm columnals)

The label of the sample from GSC locality 6570 reads "8" rather than "2" ft., which probably is a slip of the pen. Williams (1920a, p. 8; 1920b, p. 26) recorded a thickness of 2 ft. (0.61 m) for the green

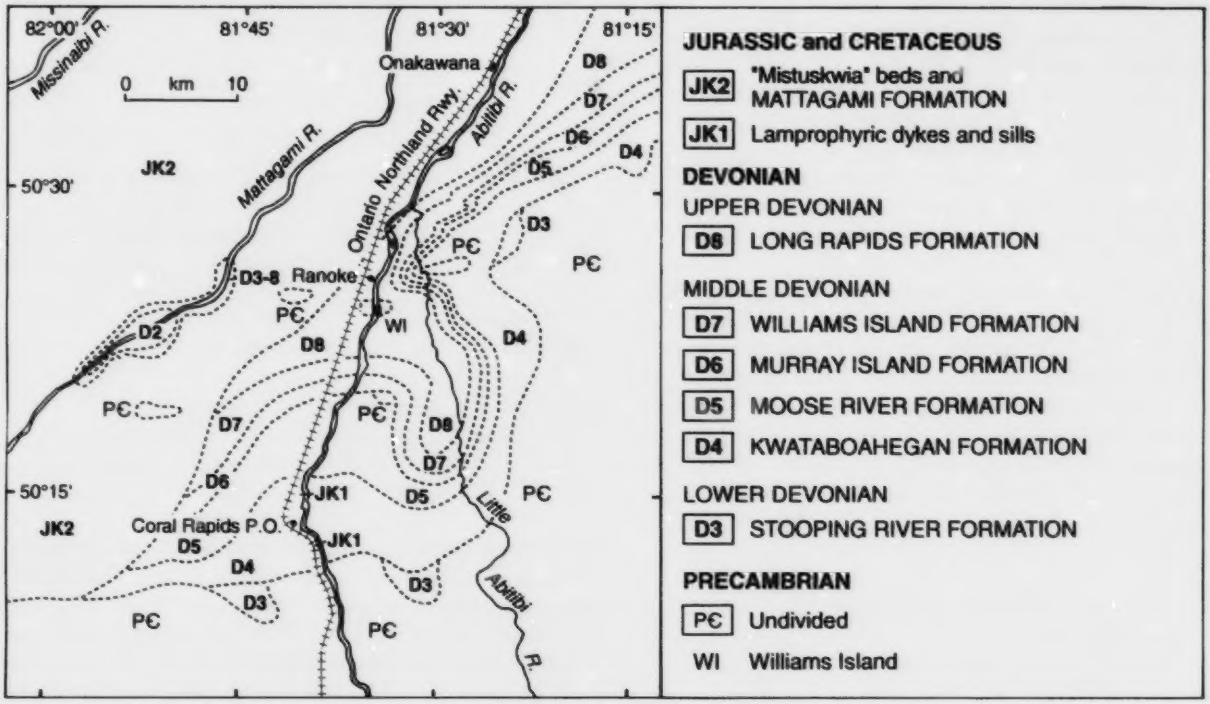

82°00'
81°45'
81°30'
81°15'
50°30'
50°15'
Missinaibi R.
0 km 10
Onakawana
Mattagami R.
Ontario Northland Rwy.
Abitibi R.
JK2
D3-8
Ranoke
D2
PC
D8
WI
D7
D6
D5
D4
D3
JK1
Coral Rapids P.O.
Little Abitibi R.
JURASSIC and CRETACEOUS
JK2 "Mistuskwia" beds and MATTAGAMI FORMATION
JK1 Lamprophyric dykes and sills
DEVONIAN
UPPER DEVONIAN
D8 LONG RAPIDS FORMATION
MIDDLE DEVONIAN
D7 WILLIAMS ISLAND FORMATION
D6 MURRAY ISLAND FORMATION
D5 MOOSE RIVER FORMATION
D4 KWATABOAHEGAN FORMATION
LOWER DEVONIAN
D3 STOOPING RIVER FORMATION
PRECAMBRIAN
PC Undivided
WI Williams Island

Figure 2. Geological map of the Williams Island area.

limestone. This is the key sample from which *Hypothyridina*, suggesting a Tully age for the uppermost Williams Island Formation, has been widely reported in the literature (e.g., Cooper et al., 1942, p. 1788). Fossils below this level in the formation were assigned a Hamilton age (Kindle, 1924, p. 34).

GSC locality 6569, below black Huron Shale (Long Rapids Formation), 400 yd. (365.8 m) below foot of limestone island (Williams Island) at foot of Long Rapids (assigned to Williams Island Formation by Wilson, but fossils suggest Long Rapids Formation):

Chonetes sp. C [*Strophodonta* (*Strophodonta*) sp.]
Leiorhynchus sp. A (cf. *Calvinaria* sp. A)
cf. *Centronella* sp. (cf. *Cranaena* sp.)

GSC locality 6571, 500 yd. (457.2 m) south of first island (Williams Island) in series in Long Rapids (going upstream), part of the Williams Island Formation:

Favosites cf. *hamiltoniae* Hall

Wilson (1953, p. 74) concluded that the fossils in the four Geological Survey of Canada collections indicated a Hamilton or early Portage age.

Having re-examined the fossils collected by M.Y. Williams from GSC localities 6570 and 6569, one of the writers (AWN) concludes that the beds represented

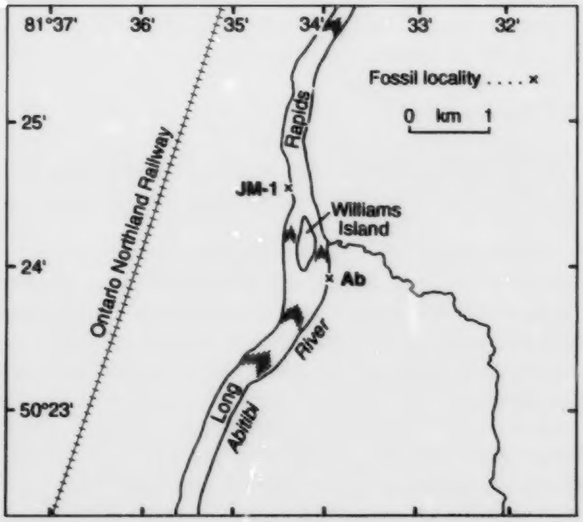

81°37'
36'
35'
34'
33'
32'
25'
24'
50°23'
Fossil locality .... ×
0 km 1
Ontario Northland Railway
Long Rapids
JM-1
Williams Island
Ab
Abitibi River

Figure 3. Localities of fossil collections described in the report from the Williams Island area.

are a lower part of the Long Rapids Formation rather than the upper part of the Williams Island Formation. The presence of *Calvinaria* sp. A in both samples indicates a Frasnian rather than a Givetian age.

Fritz et al. (1957), in their study of the type section of the upper member of the Williams Island Formation in 1953, collected fossils from the lower 22 ft. (6.7 m) of the composite section, which they determined to be 133 ft. (40.5 m) thick. In contrast to previously reported faunas from the Williams Island area, the collection consisted largely of corals, some stromatoporoids and echinoderm columnals, and very few brachiopods. Their list of fossils and source beds, in descending order, are as follows (op. cit., Pl. 1):

Unit 7	*Thamnopora martisoni* Fritz, Lemon, and Norris *Hexagonaria williamsi* (Fritz, Lemon, and Norris) *Athyris* sp. crinoid stems stromatoporoids fucoids
Unit 5	*Tortophyllum cysticum* (Winchell) *Thamnophyllum dyeri* Fritz, Lemon, and Norris *Hexagonaria williamsi* (Fritz, Lemon, and Norris) *Favosites abitibiensis* Fritz, Lemon, and Norris crinoid stems
Unit 4	*Aulopora conferta* Winchell *Aulopora michiganensis* Fenton *Favosites abitibiensis* Fritz, Lemon, and Norris *Drymopora cystiformis* Fritz, Lemon, and Norris crinoid stems
Unit 2	*Spirifer* sp.

Fritz et al. (1957, p. 25) concluded that this fauna had many elements in common with the Traverse Group of Michigan and indicated a Givetian age. The lower, argillaceous limestone beds containing this fauna were exposed in 1953 along the water's edge on the west bank of the Abitibi River opposite the middle of Williams Island. When this locality was revisited by Sanford and Norris (1975, Pls. 16, 17) in September, 1967, the beds were no longer evident; presumably they were covered by river silt and gravel, or had been stripped away by erosion.

During the summer months of 1950 to 1953, the Royal Ontario Museum of Toronto sponsored expeditions to the James Bay Lowland to investigate the Devonian rocks along the Abitibi River. During the fieldwork of 1952, J. Monteith traversed the west bank of the river in the Williams Island area and discovered the source beds of *Leiorhynchus* sp. cf. *L. quadracostatus* (Vanuxem), a species that previously had been recorded by Dyer (1928, p. 27) from this area. The Monteith collection is from argillaceous limestone beds outcropping near the water's edge on the west bank of the river about 0.25 mi. (0.40 km) north of the north end of Williams Island (Sanford and Norris, 1975, p. 70). This locality would suggest a level at or near the top of the Williams Island Formation.

One of the most recent and detailed accounts of the Williams Island and Long Rapids formations is that by Sanford and Norris (1975), which is based on new data acquired by members of the Geological Survey of Canada "Operation Winisk" in 1967. That report also summarized and reinterpreted all the previous Devonian literature on the Hudson Platform and included subsurface data up to 1972. All samples from the upper carbonate member of the Williams Island Formation submitted by Sanford and Norris (op. cit., p. 70) for conodont processing were unfortunately barren. These samples were mostly from the main exposure at the south end of Williams Island where the carbonate and shale beds are also barren of macrofossils. In the same report, the preliminary work of one of us (TTU) on conodonts from the Long Rapids Formation was summarized, based on five productive samples from scattered outcrops of the formation along Abitibi River near Williams Island (Sanford and Norris, op. cit., p. 77–79). Uyeno (*in* Sanford and Norris, 1975, p. 79) concluded that the conodont zones represented in the Long Rapids Formation range from the *Ancyrognathus triangularis* Zone (middle Frasnian) through the Middle *Palmatolepis triangularis* Zone (early Famennian). This sequence is comparable to that represented in the Sweetland Creek Shale at its type section in eastern Iowa (Klapper and Furnish, 1963). The lithology and sequence of conodonts of the Long Rapids Formation also bear some resemblance to those of the Kettle Point Formation in the Sombra 2-6 well of southwestern Ontario, as reported by Winder (1966).

Trace fossils of the Long Rapids Formation exposed on Abitibi River and in the Ontario Geological Survey Onakawana B well were studied by Bezys (1987), and summarized by Bezys and Risk (1987) (see remarks below under "Present work").

Present work

A large part of the present study is based on collections made in September, 1984, by P.G. Telford and R.K.A. Bezys, Ontario Geological Survey, Toronto (Bezys was then a student at McMaster University at Hamilton, Ontario, who studied the Abitibi River section as part of her M.Sc thesis), and B.V. Sanford of the Geological Survey of Canada, Ottawa. Almost all of the brachiopods are from the uppermost part of the Williams Island Formation. A few specimens are from thin, scattered, carbonate beds in the lower part of the overlying Long Rapids Formation. The fossils are from a measured section located along the east bank of the Abitibi River, immediately south of Williams Island where the beds have been brought to the surface by an anticlinal fold. Also included in the study are the specimens of *Leiorhynchus quadracostatus alces* Sartenaer n. subsp. collected in 1952 by J. Monteith of the Royal Ontario Museum, Toronto, from the upper part of the Williams Island Formation on the west bank of the Abitibi River north of the north end of Williams Island.

Older collections with important brachiopods examined in this study include those of Williams (1920a, b) from the west bank of the Abitibi River opposite Williams Island, and from a locality on the Mattagami River 4 mi. (6.4 km) above Pike Creek. The collection by Dyer (1928) from presumably the west side of Williams Island could not be found.

Samples from the nine conodont localities reported herein were processed at the Ontario Geological Survey, Toronto, under the supervision of P.G. Telford. A second sample from GSC locality 100799 was processed at the Institute of Sedimentary and Petroleum Geology, Calgary.

A detailed ichnological and sedimentological study of the section of the Long Rapids Formation exposed on the east bank of the Abitibi River immediately south of the south end of Williams Island was made by Bezys (1987) and its summary presented by Bezys and Risk (1985, 1987). A summary of the biostratigraphy of the same section was presented by Telford (1985).

As part of the 1985 intensive study of the Long Rapids Formation as a potential oil shale, the Ontario Geological Survey drilled a well close to the site of the original Onakawana well. The new well, referred to as the OGS Onakawana B well, is located at latitude 50°35′24″N, longitude 81°29′10″W (Sanderson and Telford, 1985). The Long Rapids Formation in the well is also included in the studies cited above (Bezys and Risk, 1985; Telford, 1985; Bezys, 1987). Conodonts from the 80 m thick interval of the Long Rapids Formation are currently being studied by T.T. Uyeno and P.G. Telford.

Responsibilities

Responsibilities for preparing this report are as follows: P.G. Telford for the stratigraphy and conodont samples, T.T. Uyeno for conodont systematics and biostratigraphy, P. Sartenaer for most of the systematics of the rhynchonellid brachiopods, and A.W. Norris for the remaining brachiopod systematics and biostratigraphy, some stratigraphy and overall coordination of the report. Because of logistics, descriptions of three of the rhynchonellid brachiopods were prepared by A.W. Norris with contributions by P. Sartenaer.

Acknowledgments

The writers thank B.C. Rutley, C.C. Ryley, W.B. Sharman, and J.N.Y. Wong of the Geological Survey of Canada, Calgary, for the photography of the fossils.

The writers are indebted to the curation staff at the Geological Survey of Canada, Ottawa, and at the Royal Ontario Museum, Toronto, for the search and loan of important fossil collections made on reconnaissance surveys by two pioneer geologists in the Moose River Basin.

We are grateful to W.W. Nassichuk of the Institute of Sedimentary and Petroleum Geology, Calgary, for identifying ammonoid specimens from the lower part of the Long Rapids Formation. W.K. Braun of the University of Saskatchewan kindly identified the only pyritized(?) ostracode recovered from acid-digested residues.

A. Lenz of the University of Western Ontario, London, and P. Bultynck of the Institut royal des Sciences naturelles de Belgique, Brussels, critically reviewed the brachiopod and conodont sections, respectively, of the manuscript, and provided helpful comments for improving the report.

STRATIGRAPHY

Beds designated as the Williams Island and Long Rapids formations represent the two upper rock units of the Devonian succession of the Moose River Basin (Figs. 1, 2). These two formations occupy a central part of the basin, but are largely covered by Mesozoic, Pleistocene, and Recent deposits. In the Williams Island area along the Abitibi River, strata from the formations are brought to the surface by a west-southwest trending anticlinal fold (Fritz et al., 1957, Pl. 1), which appears to be continuous with the upward arching of beds present in the Grand Rapids area on the Mattagami River to the west (Fig. 1). The composite thickness of the Devonian succession in the Moose River Basin is about 400 m (Norris, 1986, p. 31). The Devonian stratigraphy of the Moose River Basin was summarized recently by Norris (1986) and Telford (1989).

Williams Island Formation

The name Williams Island Limestone was introduced by Kindle (1924, p. 30, 34, 35) for the succession of carbonate and shale exposed on Williams Island and adjacent banks of the Abitibi River near the downstream end of Long Rapids. In current usage, the Williams Island Formation is defined as the beds disconformably overlying limestone of the Murray Island Formation, and underlying dark shale of the Long Rapids Formation. Throughout the Moose River Basin, the Williams Island Formation consists of a lower, recessive, argillaceous member, and an upper, resistant, carbonate member.

In the Moose River Basin, representative thicknesses of the lower member vary from 36 to 47 m, and the upper member from 33 to 45 m (Norris, 1986, p. 35).

The lower member of the formation, exposed on Mike Island, Moose River, typically consists of soft, grey shale; irregularly bedded, soft sandstone; gypsiferous, sandy shale; gypsiferous siltstone and sandstone; soft limestone; and some brecciated limestone. At several other localities in the Moose River Basin the basal beds of the formation consist of abundantly fossiliferous, bluish grey, "clay-shale" that weathers a brick-red colour (Sanford and Norris, 1975, p. 63). This unit appears to have a discontinuous and sporadic distribution in the basin.

The upper member of the formation is exposed on Williams Island and adjacent banks of the Abitibi River, and typically consists of thin to medium bedded, argillaceous limestone; calcareous shale; medium to coarse grained saccharoidal and oolitic limestone; platy, argillaceous limestone; and partly brecciated, vuggy, oolitic limestone (Fritz et al., 1957, p. 22-24, Pl. 1). The lower 17.7 m of this section are more argillaceous and recessive compared to the upper 22.6 m, which contain more resistant carbonate.

Overlying the top of the above section are 1.3 m of pale green, "clay-shale" containing three thin, concretionary, calcareous layers and abundant brachiopods (decribed in this report) and other fossils at the base (Fig. 4). The contact of the green "clay-shale" with the underlying thick bedded limestone is not exposed, but, judging from the exposures on Williams Island and the adjacent east bank of the Abitibi River, the covered interval separating the exposures would be thin, probably in the order of 1 m thick. The 1.3 m thick green "clay-shale" is here considered a part of the Williams Island Formation, although it may be argued that it more properly belongs in the Long Rapids Formation. It is placed in the former formation because both the lithology and the fossils are more closely related to those of the underlying beds of the Williams Island Formation than they are to the beds of the overlying Long Rapids Formation. In addition, the megafossils from the green "clay-shale" unit are representative of forms that all previous workers considered to be typical of the upper Williams Island Formation.

In the core from the Onakawana B well, it is evident that an erosional surface separates the base of the green, "clay-shale" unit, which is about 4 m thick, from the top of the restricted marine carbonate of the Williams Island Formation.

The brachiopods and corals from the lower, argillaceous member of the formation in Moose River Basin are identical or closely similar to forms that occur in the Hamilton Group of southwestern Ontario and New York State, which are dated as Givetian (Sanford and Norris, 1975).

A fauna consisting largely of corals from the lower part of the upper member of the Williams Island Formation contains many elements in common with the Traverse Group of Michigan, which is dated as Givetian (Fritz et al., 1957).

Spores from the lower part of the formation in Moose River Basin are assigned to the upper part of the *devonicus-orcadensis* Assemblage Zone (see Figure 5), which is dated as early to middle Givetian (McGregor and Camfield, 1976).

The age of brachiopods and conodonts from the uppermost Williams Island Formation are discussed below under "Biostratigraphy".

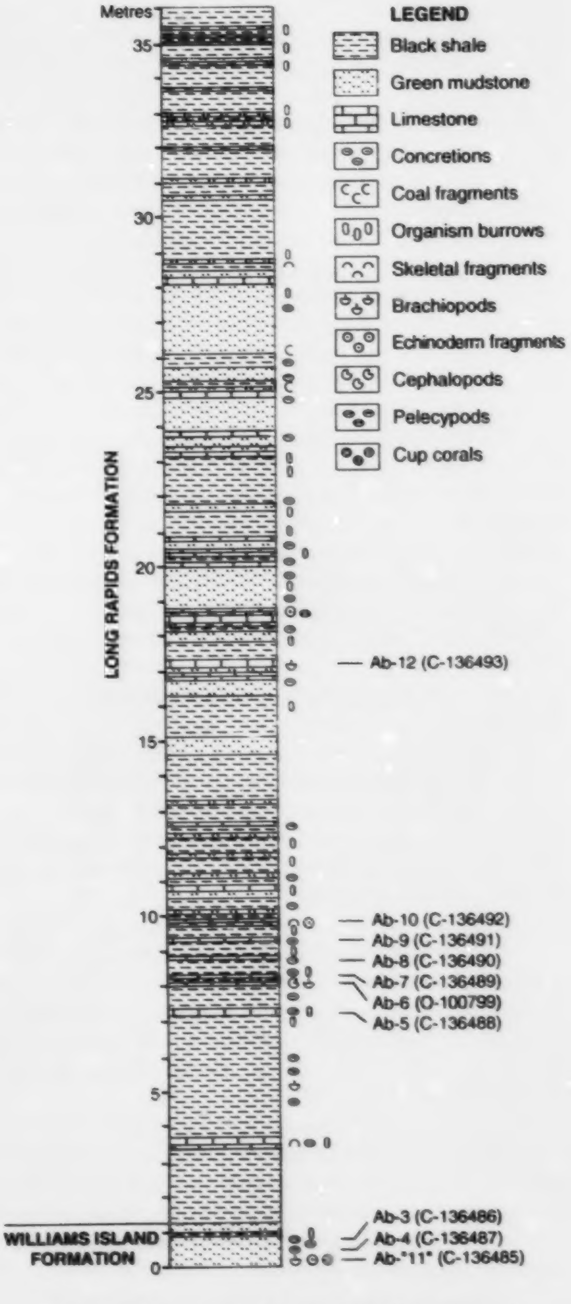

Metres
35
30
25
20
15
10
5
0
LONG RAPIDS FORMATION
WILLIAMS ISLAND FORMATION
LEGEND
Black shale
Green mudstone
Limestone
Concretions
Coal fragments
Organism burrows
Skeletal fragments
Brachiopods
Echinoderm fragments
Cephalopods
Pelecypods
Cup corals
Ab-12 (C-136493)
Ab-10 (C-136492)
Ab-9 (C-136491)
Ab-8 (C-136490)
Ab-7 (C-136489)
Ab-6 (O-100799)
Ab-5 (C-136488)
Ab-3 (C-136486)
Ab-4 (C-136487)
Ab-"11" (C-136485)

***Figure 4.** Stratigraphic section of uppermost Williams Island Formation and lower Long Rapids Formation, measured on the east bank of the Abitibi River opposite the south end of Williams Island.*

Long Rapids Formation

The name Long Rapids Shale was introduced by Savage and Van Tuyl (1919, p. 341, 373, 377) for the grey to black Upper Devonian shale exposed along Abitibi River in the vicinity of Long Rapids. These beds overlie the upper member of the Williams Island Formation, consisting mainly of carbonate rocks, and are unconformably overlain by continental beds of sand, clay, and lignite of Mesozoic age in the Moose River Basin (Sanford and Norris, 1975, p. 72).

The main exposures of the Long Rapids Formation are along the Abitibi River where they outcrop discontinously over distances of 2.4 km above and 3.2 km below Williams Island. Four other small and scattered exposures are known in the basin. The best and most complete outcrop section is that measured and studied by R.K.A. Bezys and P.G. Telford in 1984 on the east bank of the Abitibi River opposite the south end of Williams Island, where 35 m of the formation are exposed (Fig. 4).

Where the Long Rapids Formation is penetrated in the subsurface of Moose River Basin, recorded thicknesses vary from 12 to 87 m. The thickest section is located in the Onakawana area (Fig. 2), where less erosion has occurred at the top of the sequence. The Ontario Geological Survey Onakawana B well penetrated 80 m of the formation (Sanderson and Telford, 1985; Telford, 1985).

The Long Rapids Formation consists mainly of dark, petroliferous shale, with some interbedded green-grey, variably calcareous claystone, minor thin beds of limestone, and scattered, thin, concretionary, iron-rich carbonate layers. In the section measured in detail, the dark shale makes up 69 per cent, the green claystone, 23 per cent, and the limestone beds and concretionary layers, 8 per cent, of the exposed part of the formation.

The base of the Long Rapids Formation is here selected at the base of the first appearance of dark shale that forms the major component of the formation. This definition does not include the relatively thin unit of green, calcareous "clay-shale" separating the top of the restricted marine carbonate of the Williams Island Formation from the base of the dark shale of the Long Rapids Formation. This green "clay-shale", as indicated above, is assigned to the Williams Island Formation. In core from the Onakawana B well, an erosion surface is evident at the top of the green, "clay-shale" unit (about 4 m thick) immediately below the first appearance of dark shale.

The top of the "clay-shale" unit is marked by a thin layer of small, phosphatic nodules about 1 mm in diameter, lingulid fragments, some pyritization and calcification, and abundant, fragmentary, calcareous brachiopod shells.

The Long Rapids Formation has yielded a low diversity of fossils. The large sporomorph, *Tasmanites huronensis* (Dawson), and occasional lingulid brachiopods and conodonts are the most common fossils recovered from the dark shale. The few other fossils from the formation include tentaculitids, brachiopods, ammonoids, echinoderm columnals, fragmentary fish plates, and plant tissue, which appear to be confined to the lighter coloured carbonate beds. Bezys and Risk (1985) reported that bioturbation was a common feature in the greenish grey beds but rare in the dark shale. Trace fossils listed by them include *Zoophycos, Teichichnus, Planolites*, and *Chondrites*. *Chondrites* was the most common, and occasionally crosscut the other burrows.

Preliminary work by Uyeno and reported by Telford (1985) on the conodonts of the Long Rapids Formation, as defined in this report, has indicated species from five standard Upper Devonian zones, ranging from the early Frasnian Middle *asymmetrica* Zone to the middle Famennian Lower *rhomboidea* Zone (Fig. 5). The Frasnian-Famennian boundary, according to Telford (1985), lies about 35 m above the base of the formation.

The age of the brachiopods and conodonts described in this report from the Long Rapids Formation are discussed below under "Biostratigraphy".

BIOSTRATIGRAPHY

Brachiopods

A relatively rich and diverse brachiopod fauna has been recovered from locality Ab-"11" (= GSC loc. C-136485), from the uppermost unit of the Williams Island Formation. The fauna comprises the following species (Figs. 3, 4):

Schizophoria sp. cf. *S. athabaskensis* Warren
Strophodonta (*Strophodonta*) *abitibiensis* Norris n. sp.
Nervostrophia ralla Norris n. sp.
Eostrophalosia parksi Norris n. sp.
Ladogioides pusilla Sartenaer n. sp.
Leiorhynchus quadracostatus alces Sartenaer n. subsp.
Atryparia rubra Cooper and Dutro
Desquamatia (*Independatrypa*) *exila* Norris n. sp.
Desquamatia (*Independatrypa*) sp. A
Desquamatia (*Independatrypa*) sp. B
Spinatrypa (*Spinatrypa*) sp. A
Spinatrypa (*Spinatrypa*) *tribulosa* Norris n. sp.
Emanuella martisoni Norris n. sp.
Ladjia? *plicata* Norris n. sp.
Cyrtina sp. cf. *C. triquetra* (Hall)
Tecnocyrtina bicostata Norris n. sp.
Mucrospirifer williamsi Norris n. sp.

Also present in this unit, but not studied, are the following:

Tabulophyllum sp. [to be studied by A.E.H. Pedder]
echinoderm ossicle with single axial canal
Pleurotomaria sp.
Phacops sp.

The fauna from the uppermost Williams Island Formation occurs about 112 ft. (34.1 m) above the fauna recorded by Fritz et al. (1957) from the lower 22 ft. (6.7 m) of the upper member of the formation, from beds that were formerly exposed on the west bank of the Abitibi River opposite Williams Island. This latter fauna, characterized by *Hexagonaria williamsi* (Fritz et al., 1957), and consisting mainly of corals, has many features in common with the Traverse Group of Michigan and was dated as Givetian in age. The first significant megafauna found above that of the uppermost Williams Island Formation occurs in a limestone bed containing goniatites and fragmentary brachiopods (GSC loc. 100799). This bed, 5 cm thick, occurs within dark shale 6.9 m above the base of the Long Rapids Formation in a section measured on the east bank of the Abitibi River near the south end of Williams Island. The goniatites were identified by Miller (1938, p. 115, 116) as *Manticoceras* sp. cf. *M. sinuosum* (Hall) in early collections by Savage and Van Tuyl (1919), and this identification has been confirmed by W.W. Nassichuk (pers. comm. to P.G. Telford, 1986) from more recent sequentially collected material. The associated brachiopods, although fragmentary, are described and illustrated in this report as Calvinariid sp. Two important brachiopods frequently mentioned in the literature, collected by Williams (1920a, p. 8, 1920b, p. 26) in 1919 from the west bank of the Abitibi River opposite Williams Island, are also described and illustrated in this report as *Hypothyridina*? sp. A and *Calvinaria* sp. A. Although considered by many authors to be from the uppermost Williams Island Formation, they are from strata placed here in the Long Rapids Formation.

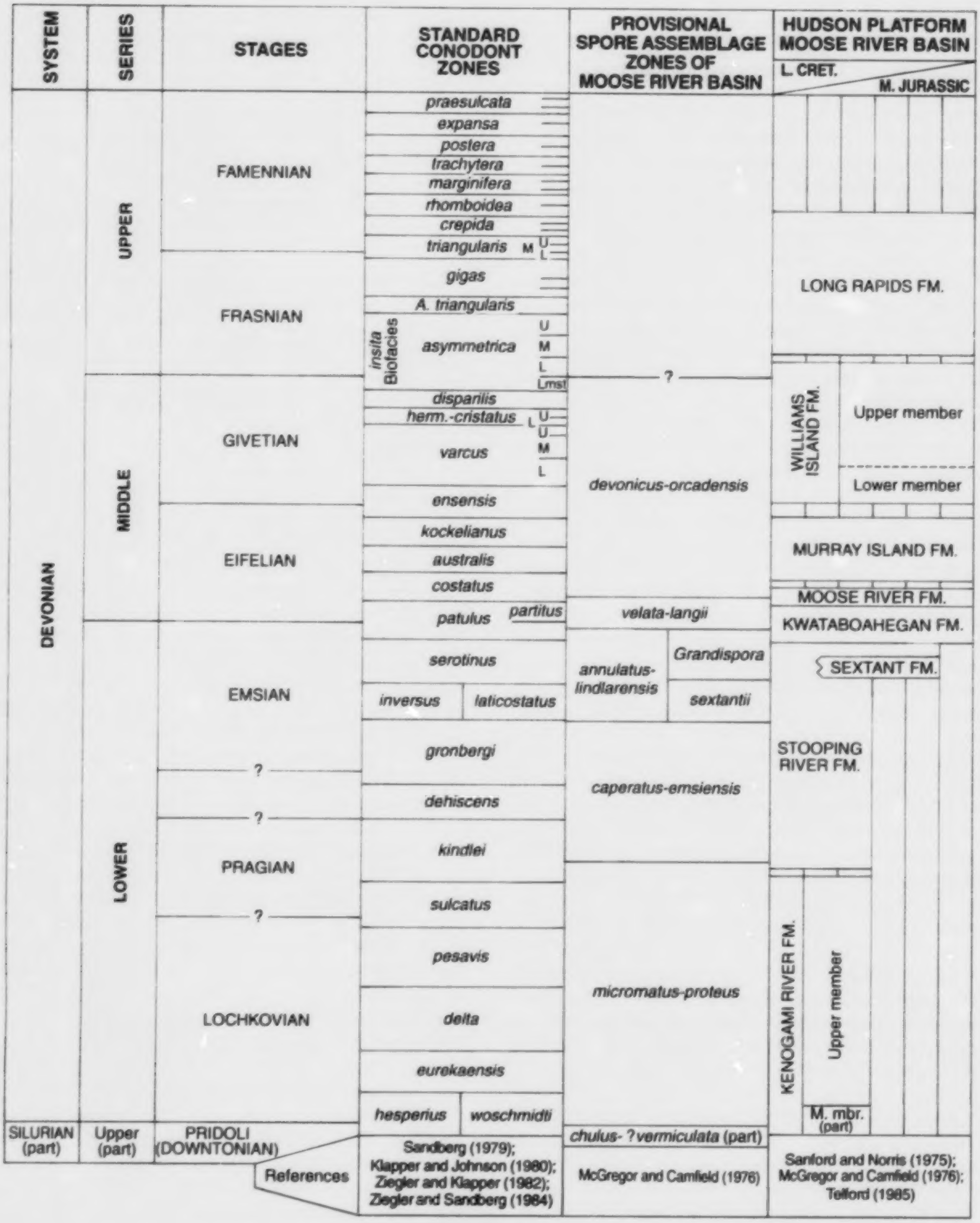

SYSTEM
SERIES
STAGES
STANDARD CONODONT ZONES
PROVISIONAL SPORE ASSEMBLAGE ZONES OF MOOSE RIVER BASIN
HUDSON PLATFORM MOOSE RIVER BASIN
L. CRET.
M. JURASSIC
DEVONIAN
UPPER
MIDDLE
LOWER
FAMENNIAN
FRASNIAN
GIVETIAN
EIFELIAN
EMSIAN
PRAGIAN
LOCHKOVIAN
?
praesulcata
expansa
postera
trachytera
marginifera
rhomboidea
crepida
triangularis
M
U
L
gigas
A. triangularis
insita Biofacies
asymmetrica
U
M
L
Lmst
disparilis
herm.-cristatus
L
U
U
M
L
varcus
ensensis
kockelianus
australis
costatus
patulus
partitus
serotinus
inversus
laticostatus
gronbergi
dehiscens
kindlei
sulcatus
pesavis
delta
eurekaensis
hesperius
woschmidti
devonicus-orcadensis
velata-langii
annulatus-lindlarensis
Grandispora
sextantii
caperatus-emsiensis
micromatus-proteus
chulus- ? vermiculata (part)
LONG RAPIDS FM.
WILLIAMS ISLAND FM.
Upper member
Lower member
MURRAY ISLAND FM.
MOOSE RIVER FM.
KWATABOAHEGAN FM.
SEXTANT FM.
STOOPING RIVER FM.
KENOGAMI RIVER FM.
Upper member
M. mbr. (part)
SILURIAN (part)
Upper (part)
PRIDOLI (DOWNTONIAN)
References
Sandberg (1979); Klapper and Johnson (1980); Ziegler and Klapper (1982); Ziegler and Sandberg (1984)
McGregor and Camfield (1976)
Sanford and Norris (1975); McGregor and Camfield (1976); Telford (1985)

Figure 5. Devonian formations in the Moose River Basin of the Hudson Platform in northern Ontario, correlated approximately with the standard conodont zones and provisional spore assemblage zones.

Analysis of the affinities of the brachiopod fauna from the uppermost Williams Island Formation, revealed four divisions of affinity of related forms. The distribution of the related forms are shown in Figure 6. Because 11 of the 17 species described in this report are new, an attempt has been made to relate the new species to previously described, closely related forms from other areas.

In the first and most important division are three diagnostic taxa considered to be closely related or identical to previously described forms. These are *Ladogioides pusilla* Sartenaer n. sp., *Leiorhynchus quadracostatus alces* Sartenaer, n. subsp., and *Atryparia rubra* Cooper and Dutro.

The recognition of *Ladogioides pusilla* in northern Ontario is the first record of this genus in eastern North America. *Ladogioides pax* McLaren, 1962, the type species of this genus, occurs typically in the Peace Point and Firebag members of the Waterways Formation of northeastern Alberta, where it is associated with conodonts of the Lowermost *asymmetrica* Zone (Norris and Uyeno, 1983, p. 20–22, Pl. 3, fig. 1–37, Pl. 4, fig. 1–10). *Ladogioides pax* is known also from the lower Hay River Formation on the northwest side of Great Slave Lake in southern District of Mackenzie (Norris and Uyeno, 1983, p. 22), from the lower Weatherall Formation in northeastern Banks Island (Harrington, 1971, p. 788, 789, Pl. 2, fig. 18–27, Pl. 3, fig. 1–5), and more recently it has been recorded by Norris (GSC Internal Report No. 3-AWN-1986, January 27, 1986) from an isolated outcrop of the Weatherall Formation on Melville Island, south of Ibbett Bay at latitude 75°53′N, longitude 114°48′W. Its occurrence in the Alberta Rocky Mountains was noted for the first time by Norris (GSC Internal Report No. 8-AWN-1986, March 26, 1986) from 0 to 3 m above the base and 126 to 129 m below the top of the Flume Formation, in a section measured at the Ancient Wall, Alberta, 1 km north-northwest of Noonday Peak, at E3806, N59208 (NTS 83 E-7W).

Leiorhynchus quadracostatus (Vanuxem) in New York State occurs typically in the upper 8 ft. (2.4 m) of the Genesee Shale and lower 5 ft. (1.7 m) of the Sherburne Shale and Sandstone (Sartenaer, 1961, p. 967). The range of the *Leiorhynchus quadracostatus* Zone, according to Kirchgasser et al. (1986, p. 254), is from the uppermost Genesee Shale into the overlying Lodi Limestone. Evidence from conodonts for this interval indicates the presence of the Upper *disparilis* and Lowermost *asymmetrica* zones (Kirchgasser et al., 1986, p. 251, 254). Sartenaer (1985, p. 314) and Norris (1986, p. 36), in independent interpretations of distribution data, aligned the range of *L. quadracostatus* with the Lowermost *asymmetrica* conodont Zone.

There is some similarity between *L. quadracostatus* (Vanuxem) of eastern North America and *L. hippocastanea* (Crickmay, 1960) of western North America. The distribution of *L. hippocastanea* in the type lower Mackenzie Valley area seems to span an interval from the Upper *hermanni-cristatus* Subzone to the Upper *disparilis* Zone (Braun et al., 1989, p. 104).

Atryparia rubra Cooper and Dutro (1982, p. 86, Pl. 21, figs. 38–53) occurs typically in the Oñate Formation of New Mexico. This formation is aligned by Cooper and Dutro (1982, Textfig. 8) with the upper Middle *varcus* Subzone at the base and the *hermanni-cristatus* Zone at the top.

In the second level of affinity is the form designated as *Schizophoria* sp. cf. *S. athabaskensis* Warren from the Williams Island Formation, which is considered to be closely similar and possibly conspecific with the species from Alberta. *Schizophoria athabaskensis* Warren occurs typically in the *Strophodonta* (*S.*) *clearwaterensis* Zone in the Calumet Member of the Waterways Formation of northeastern Alberta (Norris and Uyeno, 1983, Fig. 4). The Calumet Member straddles the upper Lowermost and Lower *asymmetrica* conodont zones.

Cyrtina sp. aff. *C. triquetra* (Hall) is assigned a third level of affinity. The form from the Williams Island Formation most closely resembles *Cyrtina triquetra* (Hall) as described and illustrated by Stainbrook (1943b, p. 446, 447, Pl. 70, figs. 22–29) from the Cedar Valley Formation of Iowa, where it ranges from the *Acervularia profunda* Zone up to the *Cranaena iowensis* Zone, but is most common in the "*Atrypa*" *waterlooensis* Zone. In Iowa, the *waterlooensis* beds occur at the top of the Rapid Member of the Cedar Valley Formation and are within the conodont *subterminus* Fauna, which is correlated with the *disparilis* Zone (Klapper *in* Witzke et al., 1985, p. 38, Fig. 4). Stainbrook (1943b, p. 447) mentioned the occurrence of *C. triquetra* at Rock Island, Illinois, and Griesemer (1965, p. 288, Pl. 6, figs. 7–9) described the species from the Lindwurm and Berthlet members of the Milwaukee Formation of Wisconsin.

The fourth and remaining group of brachiopods from the uppermost Williams Island Formation consists largely of new species and informally designated forms, and comprises the following:

Strophodonta (*Strophodonta*) *abitibiensis* Norris n. sp.
Nervostrophia ralla Norris n. sp.
Eostrophalosia parksi Norris n. sp.
Desquamatia (*Independatrypa*) *exila* Norris n. sp.
Desquamatia (*Independatrypa*) sp. A
Desquamatia (*Independatrypa*) sp. B
Spinatrypa (*Spinatrypa*) sp. A
Spinatrypa (*Spinatrypa*) *tribulosa* Norris n. sp.
Emanuella martisoni Norris n. sp.
Ladjia? *plicata* Norris n. sp.
Tecnocyrtina bicostata Norris n. sp.
Mucrospirifer williamsi Norris n. sp.

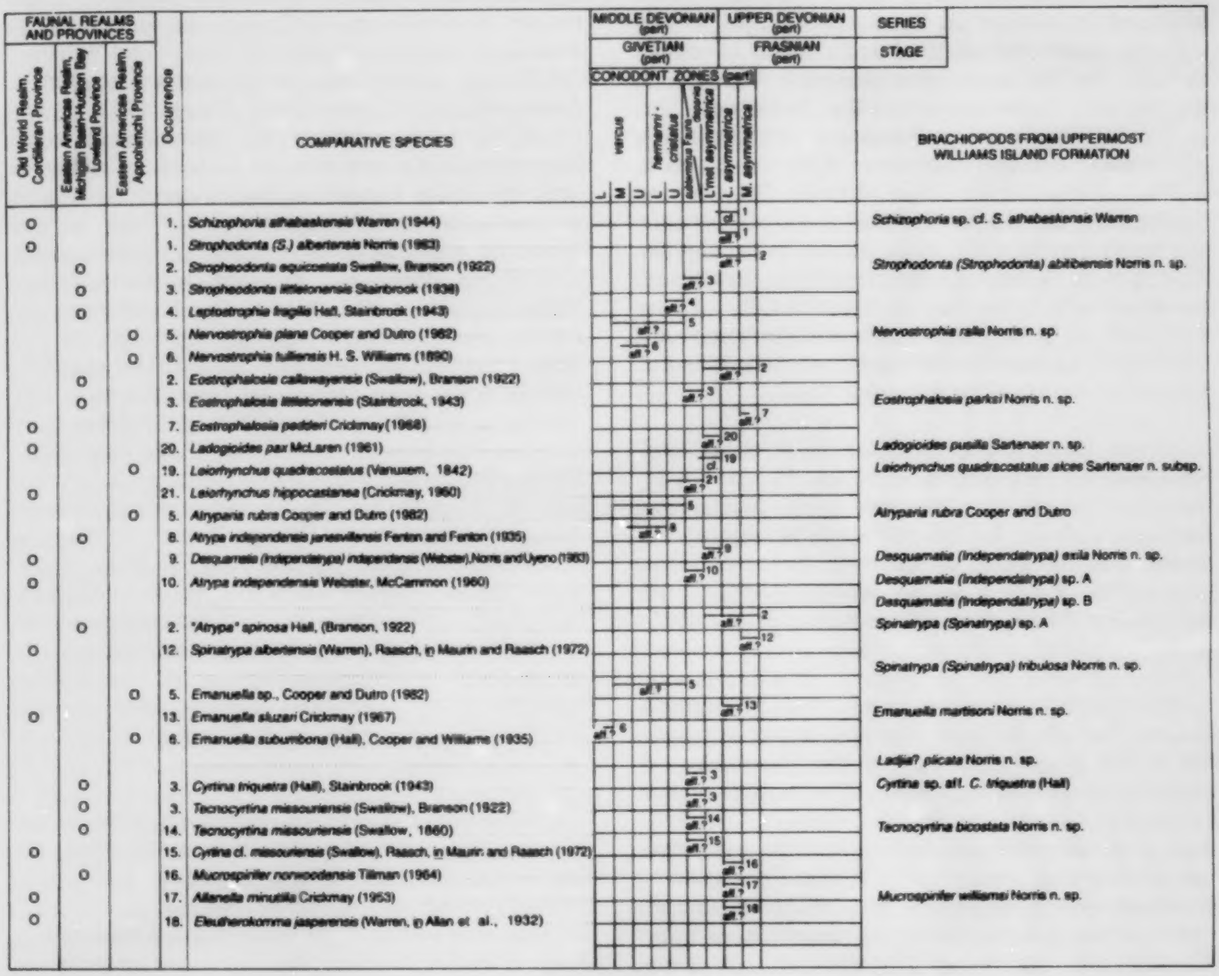
Taxonomic affinities of the new species were assessed by comparing them to forms described in the literature that appear to show close morphological similarities. Knowing the distribution and age of the comparative forms, one is in a better position to assess the age and paleogeographic source areas of the new species.

Comparative forms of *Strophodonta* (*Strophodonta*) *abitibiensis* n. sp. include *Strophodonta* (*S.*) *albertensis* Norris (1983), *Stropheodonta equicostata* Swallow (Branson, 1922), and *Stropheodonta littletonensis* Stainbrook (1938b). *Strophodonta* (*S.*) *albertensis* Norris (1983, p. 14, 15, Pl. 3, figs. 30–33, Pl. 4, figs. 1–13) occurs typically in the upper part of the Calumet Member of the Waterways Formation of northeastern Alberta, which is within the Lower *asymmetrica* conodont Zone. *Stropheodonta equicostata* Swallow is reported by Branson (1922, p. 79, 80, Pl. 11, fig. 6, Pl. 12, figs. 9–17) from the Snyder Creek Shale of Missouri, which Schumacher (1976, p. 160, Fig. 1) shows as ranging in age from Lowermost *asymmetrica* Zone at the base to Middle *asymmetrica* Zone at the top. *Stropheodonta littletonensis* Stainbrook (1938b, p. 253, 254, Pl. 34. figs. 10, 11, 14) occurs in the lower part of the "*Atrypa*" *waterlooensis* Zone of the Rapid Member of the Cedar Valley Limestone of Iowa. These beds are within the conodont *subterminus* Fauna of Klapper (*in* Witzke et al., 1985, p. 38, Fig. 4), a low diversity fauna developed in an inner shelf conodont biofacies that correlates with some part of the *disparilis* Zone developed in a basinal–outer shelf conodont biofacies.

Comparative forms of *Nervostrophia ralla* n. sp. include *Leptostrophia fragilis* Hall (Stainbrook, 1943a), *Nervostrophia plana* Cooper and Dutro (1982), and *Nervostrophia tulliensis* (Williams, 1890). *Leptostrophia fragilis* Hall is recorded by Stainbrook (1943a, p. 40, Pl. 6, figs. 5–7) from the middle part of the *Spinatrypa bellula* Zone of the lower Rapid Member of the Cedar Valley Formation of Iowa. The *bellula* Zone occurs within the conodont *hermanni–cristatus* Zone with the middle part of the *bellula* Zone probably occupying a position within the Upper *hermanni–cristatus* Subzone (Klapper *in* Witzke et al., 1985, p. 37, 38, Fig. 6). *Nervostrophia plana* Cooper and Dutro (1982, p. 48, Pl. 6, fig. 106, Textfig. 8) occurs in the Oñate Formation of New Mexico, which ranges from the upper Middle *varcus* Subzone at the base to the *hermanni–cristatus* Zone at the top. *Nervostrophia tulliensis* (H.S. Williams, 1890, Pl. 12, figs. 1–4; A. Williams, 1953a, Pl. 10, figs. 5, 8) is reported by Cooper and Williams (1935, p. 856) from the Tinkers Falls and Apulia members of the lower part of the Tully Formation of New York State, suggesting an alignment with the Middle *varcus* Subzone.

Comparative forms of *Eostrophalosia parksi* n. sp. include *E. callawayensis* (Swallow), *E. littletonensis* (Stainbrook), and *E. pedderi* Crickmay. *Eostrophalosia callawayensis* (Swallow) is recorded by Branson (1922, p. 85, 86, Pl. 11, figs. 10, 16, Pl. 15, figs. 10, 11, 13, 14, Pl. 23, figs. 18, 19) from the Snyder Creek Shale, Callaway County, Missouri. As indicated above, this formation ranges from the Lowermost *asymmetrica* Zone at the base to the Middle *asymmetrica* Zone at the top (Schumacher, 1976, p. 160, Fig. 1). *Eostrophalosia littletonensis* Stainbrook (1943a, p. 58, Pl. 7, figs. 32–37) occurs typically in the "*Atrypa*" *waterlooensis* Zone of the Rapid Member of the Cedar Valley Limestone of Iowa, which, as previously mentioned, contains the conodont *subterminus* Fauna of Klapper (*in* Witzke et al., 1985, p. 38, Fig. 4). *Eostrophalosia pedderi* Crickmay (1963, p. 17, Pl. 5, figs. 10–15, Pl. 12, figs. 6–12) occurs typically in the upper part of the lower half of the Moberly Member of the Waterways Formation of northeastern Alberta (Norris, 1983, p. 6, Fig. 4), which is within the brachiopod *Allanella allani* Zone of Crickmay (1957) and is in turn within the lower part of the Middle *asymmetrica* conodont Zone (Uyeno, 1974).

Comparative forms of *Desquamatia* (*Independatrypa*) *exila* n. sp. include *Atrypa independensis janesvillensis* Fenton and Fenton (1935), *Desquamatia* (*Independatrypa*) *independensis* (Webster) of Norris and Uyeno (1983), *Atrypa independensis* Webster of McCammon (1960), and a "discoid" *Atrypa* sp. of Maurin and Raasch (1972). *Atrypa independensis janesvillensis* Fenton and Fenton (1935, p. 379, Pl. 42, figs. 9–13) occurs in the lower Cedar Valley Limestone of Iowa in beds referred to as the *independensis* Zone by Stainbrook (1938b, p. 231). The lower part of the



FAUNAL REALMS AND PROVINCES					
Old World Realm, Cordilleran Province	Eastern Americas Realm, Michigan Basin-Hudson Bay Lowland Province	Eastern Americas Realm, Appohimchi Province	Occurrence	COMPARATIVE SPECIES	BRACHIOPODS FROM UPPERMOST WILLIAMS ISLAND FORMATION
O			1.	*Schizophoria athabaskensis* Warren (1944)	*Schizophoria* sp. cf. *S. athabaskensis* Warren
O			1.	*Strophodonta (S.) albertensis* Norris (1983)	
	O		2.	*Stropheodonta equicostata* Swallow, Branson (1922)	*Strophodonta (Strophodonta) abitibiensis* Norris n. sp.
	O		3.	*Stropheodonta littletonensis* Stainbrook (1938)	
	O		4.	*Leptostrophia fragilis* Hall, Stainbrook (1943)	
		O	5.	*Nervostrophia plana* Cooper and Dutro (1982)	*Nervostrophia ralla* Norris n. sp.
		O	6.	*Nervostrophia tullensis* H. S. Williams (1890)	
	O		2.	*Eostrophalosia callawayensis* (Swallow), Branson (1922)	
	O		3.	*Eostrophalosia littletonensis* (Stainbrook, 1943)	*Eostrophalosia parksi* Norris n. sp.
O			7.	*Eostrophalosia peddleri* Crickmay (1968)	
O			20.	*Ladogioides pax* McLaren (1961)	*Ladogioides pusilla* Sartenaer n. sp.
		O	19.	*Leiorhynchus quadracostatus* (Vanuxem, 1842)	*Leiorhynchus quadracostatus alces* Sartenaer n. subsp.
O			21.	*Leiorhynchus hippocastanea* (Crickmay, 1960)	
		O	5.	*Atryparia rubra* Cooper and Dutro (1982)	*Atryparia rubra* Cooper and Dutro
	O		8.	*Atrypa independensis janesvillensis* Fenton and Fenton (1935)	
O			9.	*Desquamatia (Independatrypa) independensis* (Webster), Norris and Uyeno (1983)	*Desquamatia (Independatrypa) exila* Norris n. sp.
O			10.	*Atrypa independensis* Webster, McCammon (1960)	*Desquamatia (Independatrypa)* sp. A
					Desquamatia (Independatrypa) sp. B
	O		2.	"*Atrypa*" *spinosa* Hall, (Branson, 1922)	*Spinatrypa (Spinatrypa)* sp. A
O			12.	*Spinatrypa albertensis* (Warren), Raasch, in Maurin and Raasch (1972)	
					Spinatrypa (Spinatrypa) tribulosa Norris n. sp.
		O	5.	*Emanuella* sp., Cooper and Dutro (1982)	
O			13.	*Emanuella sluzari* Crickmay (1967)	*Emanuella martisoni* Norris n. sp.
		O	6.	*Emanuella subumbona* (Hall), Cooper and Williams (1935)	
					Ladjia? plicata Norris n. sp.
	O		3.	*Cyrtina triquetra* (Hall), Stainbrook (1943)	*Cyrtina* sp. aff. *C. triquetra* (Hall)
	O		3.	*Tecnocyrtina missouriensis* (Swallow), Branson (1922)	
	O		14.	*Tecnocyrtina missouriensis* (Swallow, 1860)	*Tecnocyrtina bicostata* Norris n. sp.
O			15.	*Cyrtina* cf. *missouriensis* (Swallow), Raasch, in Maurin and Raasch (1972)	
	O		16.	*Mucrospirifer norwoodensis* Tillman (1964)	
O			17.	*Allanella minutilla* Crickmay (1953)	*Mucrospirifer williamsi* Norris n. sp.
O			18.	*Eleutherokomma jasperensis* (Warren, in Allan et al., 1932)	

Figure 6. *Distribution chart for species identical or closely related to those occurring in the uppermost Williams Island Formation. (x, identical; cf., similar, possibly conspecific; aff., closely related; aff.?, related but not conspecific; O, occurrence.)*

Occurrences: *1. Calumet Member, Waterways Formation, northeastern Alberta; upper Lowermost to Lower* ***asymmetrica*** *zones; 2. Snyder Creek Shale, Missouri; Lowermost to Middle* ***asymmetrica*** *zones; 3. Rapid Member, Cedar Valley Formation, Iowa;* ***Desquamatia waterlooensis*** *Zone;* ***subterminus*** *Fauna; 4. Rapid Member, Cedar Valley Formation, Iowa and Illinois;* ***Spinatrypa bellula*** *Zone; Upper* ***hermanni-cristatus*** *Subzone; 5. Oñate Formation, New Mexico; Middle* ***varcus*** *Subzone to* ***hermanni-cristatus*** *Zone; 6. Tinker Falls and Apulia members, Tully Formation, New York; Middle* ***varcus*** *Subzone; 7. Moberly Member, lower part, Waterways Formation; lower Middle* ***asymmetrica*** *Zone; 8. Solon Member, Cedar Valley Formation, Iowa; upper Middle* ***varcus*** *Subzone; 9. Peace Point Member, Waterways Formation, northeastern Alberta; Lowermost* ***asymmetrica*** *Zone; 10. Argillaceous limestone beds, Point Wilkins Member, Souris River Formation, Manitoba;* ***subterminus*** *Fauna of* ***disparilis*** *Zone; 11. Flume Formation, upper part, Kakwa Lake, British Columbia;* ***Atrypa gregeri*** *Zone; Assemblage 4 (not shown); 12. Flume Formation, top, Kakwa Lake, British Columbia; top of* ***Atrypa gregeri*** *Zone; top of Assemblage 4; 13. Waterways Formation equivalent, northern Alberta;* ***Eleutherokomma jasperensis*** *Zone; Lower* ***asymmetrica*** *Zone; 14. Rapid Member, Cedar Valley Formation, Iowa;* ***Desquamatia waterlooensis*** *Zone;* ***subterminus*** *Fauna; and Callaway Limestone, Missouri; 15. Flume Formation, lower part, Wallbridge Mountain, British Columbia; Assemblage 2;* ***disparilis*** *Zone; 16. Petoskey Formation, upper part, Michigan; Lower* ***asymmetrica*** *Zone; 17. Flume (Maligne) Formation, uppermost part, Cold Sulphur Spring, near Jasper, Alberta; Lower* ***asymmetrica*** *Zone; 18. Waterways Formation, Birch River, Alberta;* ***Ladogioides asmenista-Eleutherokomma jasperensis*** *Fauna; Lower* ***asymmetrica*** *Zone; 19. Genesee Shale, Sherburne Shale, and Lodi Limestone, New York State; upper* ***disparilis*** *and Lower* ***asymmetrica*** *zones; 20. Peace Point and Firebag members, Waterways Formation; Lowermost* ***asymmetrica*** *Zone; 21. Ramparts Formation, upper part, lower Mackenzie Valley area; Upper* ***hermanni-cristatus*** *Subzone to upper* ***disparilis*** *Zone.*

Solon Member of the Cedar Valley Limestone of Iowa is aligned by Klapper (*in* Witzke et al., 1985, p. 37) with the upper part of the Middle *varcus* conodont Subzone, and the upper Solon Member is aligned with the Lower *hermanni-cristatus* Subzone. The intervening Upper *varcus* Subzone is apparently not represented and there appears to be no physical discontinuity within the Solon Member. ***Desquamatia* (*Independatrypa*) *independensis*** (Webster) of Norris (*in* Norris and Uyeno, 1983, p. 24, 25, Pl. 5, figs. 14-23, Pl. 8, figs. 5, 6) occurs in the Peace Point Member of the Waterways Formation of Gypsum Cliffs, Peace River, northeastern Alberta, where it is within the brachiopod *Tecnocyrtina billingsi* Zone and within the Lowermost *asymmetrica* conodont Zone.

Atrypa independensis Webster as described and illustrated by McCammon (1960, p. 53, 54, Pl. 9, figs. 1, 2, 4, not fig. 3) occurs in the argillaceous limestone beds of the Point Wilkins Member of the Souris River Formation of Manitoba (Norris *in* Norris et al., 1982, p. 67), which contains conodonts of the *subterminus* Fauna (Klapper *in* Witzke et al., 1985, p. 38).

The "discoid" *Atrypa* sp. of Raasch (*in* Maurin and Raasch, 1972, Pl. 3, Pl. 12, figs. 1-7) occurs in sample 502 of the lower upper half of their Assemblage 4 (*Atrypa gregeri* Zone) from the upper Flume Formation, Kakwa Lake, British Columbia. Conodont data from this area are lacking but the associated megafauna and stratigraphic position suggests a correlation with some part of the Moberly Member of the Waterways Formation of northeastern Alberta, which in turn suggests an alignment with the lower Middle *asymmetrica* Zone.

Comparative forms of *Spinatrypa* (*Spinatrypa*) sp. A include *Spinatrypa albertensis* (Warren) of Raasch (*in* Maurin and Raasch, 1972) and "*Atrypa*" *spinosa* Hall of Branson (1922). *Spinatrypa albertensis* (Warren) of Raasch (*in* Maurin and Raasch, 1972, Pl. 3, Pl. 12, figs. 20-22) was recorded (sample 504) from the top of their Assemblage 4 (*Atrypa gregeri* Zone) of the Upper Flume Formation at Kakwa Lake, British Columbia. As indicated above, the brachiopod *gregeri* Zone is probably within the Middle *asymmetrica* conodont Zone. "*Atrypa*" *spinosa* Hall of Branson (1922, p. 98, 99, Pl. 20, figs. 8-11, Pl. 23, figs. 8, 9) was recorded from the Snyder Creek Shale of Missouri. This rock unit, as indicated above, ranges from the Lowermost *asymmetrica* Zone at the base to Middle *asymmetrica* Zone at the top (Schumacher, 1976, p. 160, Fig. 1).

Comparative forms of *Emanuella martisoni* n. sp. include *Emanuella* sp. of Cooper and Dutro (1982), *Emanuella subumbona* (Hall) of Cooper and Williams (1935), and *Emanuella sluzari* Crickmay (1967). *Emanuella* sp. of Cooper and Dutro (1982, p. 95, Pl. 26, figs. 1-6) occurs in the Oñate Formation of New Mexico. Cooper and Dutro (ibid., Textfig. 8) show the Oñate Formation ranging from the Middle *varcus* conodont Subzone at the base to the *hermanni-cristatus* Zone at the top. *Emanuella subumbona* (Hall) was recorded by Cooper and Williams (1935, p. 857, Pl. 59, figs. 8, 12) from the Apulia, New Lisbon, and Laurens members of the Tully Formation of New York State. These members are within the lower half of the Tully Formation and are aligned with the middle third of the Middle *varcus* Subzone (Kirchgasser et al., 1986, Table 7, p. 248). *Emanuella sluzari* Crickmay (1967, p. 8, Pl. 2, figs. 20-24, Pl. 3, figs. 16-20) was recorded from the *Eleutherokomma jasperensis* Zone, within the Waterways Formation of the Imperial et al. Faust South No. 6-2-72-11-W5 well at a depth of 6823 ft. (2097.7 m), northern Alberta. Conodont evidence from several localities suggests an alignment of the *jasperensis* brachiopod Zone with the Lower *asymmetrica* conodont Zone (Pollock, 1968, p. 422; Norris and Uyeno, 1981, p. 8, Table 1).

Comparative forms of *Tecnocyrtina bicostata* n. sp. include *Tecnocyrtina missouriensis* (Swallow) of Branson (1922) from Missouri, and of Stainbrook (1943b) from Iowa, and *Cyrtina* sp. cf. *C. missouriensis* of Raasch (*in* Maurin and Raasch, 1972) from British Columbia. The *Tecnocyrtina missouriensis* (Swallow) of Branson (1922, p. 108, Pl. 16, fig. 9, Pl. 19, figs. 1-4) was recorded from limestone of the Callaway Member of the Cedar Valley Formation of Missouri. Schumacher (1976, Figs. 1, 2) suggested an alignment of the Callaway beds with the *hermanni-cristatus* Zone. Fraunfelter (1968, p. 694, Figs. 1, 2) recorded the occurrence of *T. missouriensis* in Missouri from the *Hexagonaria profunda*, *Atrypa missouriensis*, and *Stropheodonta* biofacies, which he showed as being approximate lateral equivalents of one another in their distribution across central and northeastern Missouri. He (Fraunfelter, 1968, Fig. 1) correlates these biofacies of Missouri with the *Hexagonaria profunda*, *Atrypa waterlooensis*, and *Cranaena iowensis* zones, respectively, of Iowa. *Tecnocyrtina missouriensis* (Swallow) of Stainbrook (1943b, p. 447, 448, Pl. 70, figs. 6-11) and Johnson and Norris (1972, Pl. 1, figs. 5-18) was recorded from the "*Atrypa*" *waterlooensis* Zone of the Rapid Limestone of the Cedar Valley Formation of Iowa, which is placed within the *subterminus* conodont Fauna of Klapper (*in* Witzke et al., 1985, p. 38).

Comparative forms of *Mucrospirifer williamsi* n. sp. include *Mucrospirifer norwoodensis* Tillman (1964), *Eleutherokomma jasperensis* (Warren *in* Allen et al., 1932), and *Allanella minutilla* Crickmay (1953). *Mucrospirifer norwoodensis* Tillman (1964, p. 963, 964, Pl. 156, figs. 39–44) occurs in the upper part of the Petoskey Formation, Charlevoix County, Michigan. The presence of *Ancyrodella rotundiloba* (Bryant, 1921) has been reported by Bultynck (1976, p. 123, 136) from the upper Petoskey Formation of Michigan, suggesting alignment with the Lower *asymmetrica* Zone. The narrow (form A) and wide (form B) variants of *Mucrospirifer williamsi* n. sp. are comparable to *Allanella minutilla* Crickmay (1953, p. 7, Pl. 1, figs. 13–22) and *Eleutherokomma jasperensis* (Warren *in* Allan et al., 1932; Crickmay, 1953, p. 3, 4, Pl. 2, figs. 9–13). The last two species typically occur together in the uppermost Flume (now Maligne) Formation at Cold Sulphur Spring, near Jasper, Alberta (Crickmay, 1953, p. 4). Conodonts recorded by Clark and Ethington (1965, p. 383–385) from beds with the *E. jasperensis* Fauna suggest alignment with the Lower *asymmetrica* Zone. *Allanella minutilla* Crickmay and *Eleutherokomma* sp. cf. *E. jasperensis* (Warren *in* Allan et al., 1932) have been recorded also by Norris and Uyeno (1981, p. 10, 23) from the *Ladogioides asmenista–Eleutherokomma jasperensis* Fauna of the Waterways Formation in the Birch River area, northeastern Alberta, where this fauna is associated with conodonts of the Lower *asymmetrica* Zone.

In conclusion, three of the more useful taxa that show a close relationship or identity to previously described forms, *Ladogioides pusilla* Sartenaer n. sp., *Leiorhynchus quadracostatus alces* Sartenaer n. subsp., and *Atryparia rubra* Cooper and Dutro, collectively range from the Middle *varcus* conodont Subzone to the Lowermost *asymmetrica* conodont Zone. However, in the attempt to date the uppermost Williams Island Formation using brachiopod data, more reliance was placed on those species with a shorter age span and those suggesting the younger age. The first species (*L. pusilla*) is very closely related to *L. pax*, which has a short time span in terms of conodont dating as it is confined to the Lowermost *asymmetrica* Zone in its type area of northeastern Alberta. The second taxon (*L. quadracostatus alces*) is very closely related to the name bearer of the *Leiorhynchus quadracostatus* Zone in New York State where its range is aligned with the Lowermost *asymmetrica* Zone (Sartenaer, 1985, p. 314; Norris, 1986, p. 36). The third taxon (*Atryparia rubra*) occurs typically in the Oñate Formation of New Mexico, which ranges from the Middle *varcus* to the Upper *hermanni–cristatus* conodont subzones. Its presence in the uppermost Williams Island Formation could be interpreted in various ways, that is, the species could be long-ranging, or it possibly represents a reworked element from older rocks.

In the second category of affinity is *Schizophoria* sp. cf. *S. athabaskensis* Warren. *Schizophoria athabaskensis* occurs typically within the Calumet Member of the Waterways Formation of northeastern Alberta, which straddles the upper Lowermost and Lower *asymmetrica* conodont zones (Norris, 1983, p. 6, Fig. 4).

The four above-mentioned taxa in terms of affinity are considered to be the most diagnostic for dating the uppermost part of the Williams Island Formation. They suggest an alignment with the Lowermost and/or Lower *asymmetrica* conodont zones, which straddle the Middle–Upper Devonian boundary as recently defined by the International Union of Geological Sciences Subcommission on Devonian Stratigraphy (Ziegler and Klapper, 1985, p. 107, 108). If a greater emphasis is placed on the co-occurrence of *Ladogioides pusilla* and *Leiorhynchus quadracostatus alces*, a Lowermost *asymmetrica* Zone alignment and latest Middle (Givetian) Devonian age would be preferred.

The two most important megafossils in the sample from locality Ab-6 are *Manticoceras* sp. cf. *M. sinuosum* (Hall) and a species of calvinariid brachiopod. These fossils are from a thin, greyish green, limestone bed, 5 cm thick, overlain and underlain by dark grey to black shale, within the Long Rapids Formation, 8.2 m above the base of the section. The limestone bed containing the numerous goniatites is possibly a continuation of the same bed from which Savage and Van Tuyl (1919, p. 373, 374) collected four fragmentary goniatite specimens that were later described by Foerste (1928, p. 104–106, Pl. 21, figs. 2A–2E) as *Manticoceras pattersoni* (Hall), and by Miller (1938, p. 115, 116, Pl. 22, figs. 10–13) as *Manticoceras* sp. cf. *M. sinuosum* (Hall). The goniatite specimens collected but not mentioned by Savage and Van Tuyl (1919) were recorded from a unit 8 ft. (2.44 m) thick, at the top of the "Abitibi River limestone", which consists of thinly interbedded calcareous shale and irregular nodular limestone exposed beneath and separated by a sedimentary break from black shale of the Long Rapids Formation. From unit 11, Savage and Van Tuyl (1919, p. 373) listed 15 brachiopods of late Middle and early Late Devonian affinities that most later workers have placed in the

Williams Island Formation. The assemblage of brachiopods in this list is remarkably similar to that described in this report from locality Ab-"11" at the base of the section, measured on the east bank of the Abitibi River immediately south of the south end of Williams Island (Figs. 3, 4). *Manticoceras sinuosum* (Hall) in the type area of western New York ranges throughout most of the Cashaqua Shale of the Sonyea Group (Kirchgasser and House, 1981, p. 48). Most of the Cashaqua Shale, according to Klapper (1981, p. 64), is referable to the *Ancyrognathus triangularis* Zone of mid-Frasnian age. Associated with the numerous goniatites are sparse fragmentary and crushed specimens of a leiorhynchid brachiopod, one of which is an almost complete specimen that is referred to as Calvinariid sp. and compared to *Calvinaria albertensis albertensis* (Warren) described by McLaren (1962, p. 26–30, Pl. 1, figs. 1–11). This subspecies occurs most commonly in the lower and middle parts of the Mount Hawk Formation in the Front Ranges of the Alberta Rocky Mountains between the Red Deer and Smoky rivers. These beds are aligned approximately with the conodont *Ancyrognathus triangularis* Zone (Weissenberger, 1988, Fig. 44).

From locality Ab-12, three specimens of *Calvinaria* sp. cf. *C. ambigua* (Calvin) were collected by P.G. Telford in 1984 from a thin limestone bed within the Long Rapids Formation, 8.9 m above the goniatite bed of locality Ab-6, and 17.1 m above the base of the section. *Calvinaria ambigua* has been recorded from the Independence Shale of Iowa (Stainbrook, 1945, p. 44, 45) and from the High Point Sandstone of New York (Stainbrook, 1942). The conodont *Ancyrognathus triangularis* and Lower and Upper *gigas* zones occur in the Independence Shale according to Müller and Müller (1957, p. 1073, 1074, 1077–1079), and Klapper and Furnish (1963, p. 402, 408).

The *Hypothyridina*? sp. A and *Calvinaria* sp. A described in this report were collected by Williams (1920a, b) in 1919 from a 0.61 m thick bed of green, pyritic limestone with shale partings outcropping on the west bank of the Abitibi River opposite Williams Island (GSC loc. 6570; Field No. XVII). According to the conventional wisdom of that time, the presence of *Hypothyridina* indicated a correlation with the Tully Formation of New York State, which marked the base of the Upper Devonian in eastern North America. The forms of *Hypothyridina* that occur in the Tully Formation are *Hypothyridina venustula* (Hall) and its varieties *H. v. robusta* Cooper and Williams (1935, p. 841, Pl. 57, fig. 19) and *H. v. multicostata* Cooper and Williams (1935, p. 841, Pl. 57, figs. 17, 18, 20, 21). Cooper and Williams (1935, p. 823) point out that *Hypothyridina venustula* was commonly misidentified as *H. cuboides*, which characterizes the "*Cuboides* zone" at the base of the Upper Devonian in Europe. When Kindle (1924, p. 34, 35) named Williams Island and the Williams Island Limestone, the bed containing *Hypothyridina* was included in the upper part of the the formation. *Hypothyridina*? sp. A bears the closest resemblance to *Hypothyridina emmonsi rotunda* Cooper and Dutro (1982, p. 72, 73, Pl. 15, figs. 47–51), which occurs in the upper part of the Sly Gap Formation of New Mexico. The upper part of the Sly Gap Formation of New Mexico was correlated with the Upper *gigas* conodont Zone by Cooper and Dutro (1982, Textfig. 8). The closest resemblance of *Calvinaria* sp. A is with *Calvinaria ambigua* (Calvin) as described and illustrated by Stainbrook (1945, p. 44, Pl. 4, figs. 3, 4) from the Independance Shale of Iowa. Cooper and Dutro (1982, Textfig. 8) align the Independence Shale of Iowa with the Upper *gigas* conodont Zone. This dating suggests that the bed containing *Hypothyridina*? sp. A and *Calvinaria* sp. A at GSC locality 6570 on the west bank of the Abitibi River is probably equivalent to the bed at locality Ab-12 on the east bank of the Abitibi River, from which three specimens of *Calvinaria* sp. cf. *C. ambigua* (Calvin) were recorded.

Brachiopod facies, provincialism, and paleogeography

The thin, "clay-shale" unit forming the uppermost unit of the Williams Island Formation is separated by unconformities from the underlying upper member of the Williams Island Formation, and from the overlying Long Rapids Formation. It represents a transgression of open marine sediments and contains numerous fossils, in contrast to the immediately underlying restricted marine carbonates that are barren of fossils (Fritz et al., 1957). The fossils consist mainly of brachiopods and crinoid columnals concentrated mainly at the base of the unit, suggesting that they represent a lag deposit. The brachiopods are an unusual mixture of forms of different ages, derived from different facies and showing affinities to forms from different faunal provinces (Fig. 6). The relatively high number of new species and subspecies suggests that the Moose River Basin had only intermittent connection with basins to the east, south, and west during late Middle and early Late Devonian time.

The Moose River Basin of the Hudson Platform (Sanford and Norris, 1975) was placed by Oliver (1977, Fig. 1), on the basis of rugose corals, within the Hudson Bay–Michigan Basin Province of the Eastern Americas Realm during Early and Middle Devonian time. Williams Island brachiopod taxa of the Moose River Basin showing close affinity to forms from the Hudson Bay-Michigan Basin Province of the Eastern Americas Realm (Fig. 6) include *Strophodonta* (*Strophodonta*) *abitibiensis* Norris n. sp., *Eostrophalosia parksi* Norris n. sp., *Spinatrypa* (*Spinatrypa*) sp. A, and *Tecnocyrtina bicostata* Norris n. sp. Williams Island brachiopod taxa showing close affinity to forms from the Appohimchi Province of the Eastern Americas Realm include *Nervostrophia ralla* Norris n. sp., *Leiorhynchus quadracostatus alces* Sartenaer n. sp., and *Atryparia rubra* Cooper and Dutro. The remaining Williams Island taxa show close affinity to forms from the Cordilleran Province of the Old World Realm, and these include *Schizophoria* sp. cf. *S. athabaskensis* Warren, *Ladogioides pusilla* Sartenaer n. sp., *Desquamatia* (*Independatrypa*) *exila* Norris n. sp., *Desquamatia* (*Independatrypa*) sp. A, *Emanuella martisoni* Norris n. sp., and *Mucrospirifer williamsi* Norris n. sp.

Throughout most of Early and Middle Devonian time the Eastern Americas Realm was separated from the Old Word Realm of western and northern North America by the northeast-trending Transcontinental Arch. Brachiopod evidence in the Moose River Basin suggests that the Transcontinental Arch was partly breached by epicontinental seas in late Eifelian time (Norris, 1986, p. 35), and completely breached in Taghanic, mid-Givetian time (Johnson, 1970), resulting in a single cosmopolitan brachiopod fauna in the marine areas of North America and elsewhere during the Frasnian (Johnson and Boucot, 1973).

In the detailed analysis of the Long Rapids Formation by Bezys and Risk (in press), five facies are described as follows: Facies A, black shale; Facies B, bioturbated black shale; Facies C, massive green-grey mudstone; Facies D, laminated green-grey shale; and Facies E, dolomitic limestone beds and concretions. Body fossils are exceedingly sparse, occur mainly in Facies E, and include brachiopods, goniatites, crinoid columnals, bivalves, orthoconic nautiloids, gastropods, and tentaculitids. From the type of fossils in Facies E, it appears that Facies E was deposited under the most oxic conditions of the five facies in the Long Rapids Formation. The brachiopods described in this report from Facies E include *Lingula* sp., *Lingulipora* sp., *Hypothyridina*? sp. A, *Calvinaria* sp. cf. *C. ambigua* (Calvin, S., 1878), Calvinariid sp., and *Calvinaria* sp. A. Of these, *Hypothyridina* and *Calvinaria* are brachiopod genera with a cosmopolitan distribution (Johnson and Boucot, 1973, p. 94). *Lingula*, by analogy with Recent forms, is taken to be an indicator of tropical and warm temperate seas and to indicate a shallow water environment (Allan *in* Cooper, 1957, p. 801). Both lingulids and thin-shelled rhynchonellids are exclusively bottom dwellers found in mostly nearshore, shallow water deposits (Cooper, 1936-37, p. 37).

Heckel and Witzke (1979, p. 105, Textfig. 3) and Witzke and Heckel (1989, p. 53, 56, Figs. 1, 2), using the distribution of carbonates and related lithic paleoclimatic indicators for positioning Euramerica and adjacent continental blocks during the Devonian, have placed the Moose River Basin at about 29 and 28 degrees south of the paleoequator during Middle and Late Devonian time, respectively. A reconstruction by Scotese (1986), using paleomagnetic and tectonic data, shows the Moose River Basin positioned about two degrees north of the paleoequator during the Givetian, and about 10 degrees north of the paleoequator during the Famennian. Of the numerous paleobiogeographic reconstructions that have been prepared for the Devonian, there is little agreement on the precise placement of the Moose River Basin. There is general agreement, however, in placing the Moose River Basin relatively close to the Devonian paleoequator.

Conodonts

The conodont biostratigraphy of the Frasnian stage has been greatly refined recently with the studies by Mouravieff (1982) in the type area of the Ardennes, by Bultynck (1982) on the Givetian-Frasnian boundary beds, also in the type area, and by Klapper (1989b, among others), and Klapper and Lane (1989). The present work has benefited from these recent studies and, where possible, the zonation established at the sequences in the Montagne Noire in France (Klapper, 1985, 1989a) and the Alberta Rocky Mountains (Klapper and Lane, 1989) has been used. Where possible, too, correlations have been attempted with the Rocky Mountain sequences. Because some of the zonal numbering overlaps between the zonation established at these sequences, they are distinguished from each other in the following notes by the letters [MN] for Montagne Noire, and [A] for Alberta. According to Klapper (1989a, p. 450), the exact relationship of the Montagne Noire zonation to the published standard zonation is highly uncertain, especially from the base of the *Ancyrognathus triangularis* Zone upward.

Mouravieff (1982) found that the standard Upper Devonian conodont zonation, based on the pelagic succession in Germany, was not fully applicable to the shallow water Ardennes sequence. Some key palmatolepid species were missing so modification to, and enlargement of, the scope of the original zones were found necessary.

Williams Island Formation

The lowest conodont collection is from carbonate nodules in the green shale of the Williams Island Formation, located 0.7 m above the base of the section (GSC loc. C-136487; see Figs. 7, 8). The fauna consists of *Polygnathus dengleri*, *P. dubius*, and *P. pennatus*. Collectively, these species suggest a range from the *disparilis* Zone to within the Lower *asymmetrica* Zone (Zone [MN]3 of Klapper, 1989a), of late Givetian to early Frasnian age.

A small conodont faunule was obtained from the matrices of a rich brachiopod collection collected over the 1.3 m thick interval, but mainly from the lower part of this interval, of the green, "clay-shale" (GSC loc. C-136485; note that this interval is thus questionably placed in Fig. 7). The conodont faunule comprises *Polygnathus dubius*, *Icriodus symmetricus*, and a species of *Palmatolepis* that may be *P. disparilis* or *P. transitans*. This combination may suggest an assignment within the Lower *asymmetrica* Zone (Klapper *in* Klapper and Johnson, 1980; Bultynck, 1982; Klapper, 1985), of early Frasnian age.

The highest sample from within the green, "clay-shale" interval is from the uppermost 0.3 m (GSC loc. C-136486). In addition to most of the species from underlying beds, this interval contains the early and late forms (of Klapper, 1985) of *Ancyrodella rotundiloba*, and the early form of *A. alata* (of Klapper, 1985). According to Klapper (1985, 1989a), these morphotypes of *Ancyrodella* species fall within his zones [MN]1 to [MN]2 at the Montagne Noire, or approximately the lower part of the Lower *asymmetrica* Zone of Ziegler's (1962, 1971) standard zonation, of early Frasnian age. Based on sequences in other localities (Klapper, 1985), the co-occurrences of early and late forms of *A. rotundiloba* and *A. alata* suggest a mixing or reworking of conodonts, as similarly suggested by the accompanying brachiopod faunas.

Long Rapids Formation

The lowest sample (GSC loc. C-136488) from the Long Rapids Formation is from 7.4 to 7.7 m above the base of the section (= 6.1 to 6.4 m above the base of the formation), and the highest Williams Island sample. The conodont faunule from it comprises *Mehlina*? sp. cf. *M. gradata*, *Palmatolepis* sp. A, and indeterminate species of *Ancyrodella* and *Polygnathus*. *Mehlina gradata* is a long-ranging species, spanning from the Lowermost *asymmetrica* Zone to approximately Upper *gigas* Zone (Klapper *in* Klapper and Johnson, 1980; Klapper and Lane, 1985).

The bed bearing *Manticoceras* sp. cf. *M. sinuosum*, at 8.2 to 8.3 m above the base of the section (GSC loc. 100799) yielded, aside from *Icriodus symmetricus* and *Mehlina*? sp. cf. *M. gradata* that continue up from below, *Palmatolepis kireevae*, *Ancyrodella nodosa*, *Polygnathus* sp. cf. *P. decorosus*, and small specimens that may be assignable to *Ancyrognathus triangularis*. In terms of Klapper's (1989a) zonation, this fauna is approximately equivalent to the upper part of Zone [MN]10 and the lower part of Zone [MN]11, or Zone [A]4b of Klapper and Lane (1989).

GSC localities C-136490 and C-136491, from, respectively, 8.9 to 9.0 m, and 9.4 to 9.5 m above the base of the section, have similar conodont faunas. New additions at these levels include *Ozarkodina postera*, *Palmatolepis domanicensis*, *P. unicornis*, *Polygnathus* sp. cf. *P. aspelundi*, *P. decorosus*, *P. evidens*, and *Ancyrognathus euglypheus* sensu Coen (1973). A single large specimen that can be assigned without question to *Ancyrognathus triangularis* appears for the first time at GSC loc. C-136490. This faunal combination suggests an assignment to Klapper's (1989a) Zone [MN]11, or Zone [A]5b of Klapper and Lane (1989), and approximately the *Ancyrognathus triangularis* Zone of Ziegler (1962), of mid-Frasnian age.

The highest sample in this study is from an interval of 17.3 to 17.4 m above the base of the section (GSC loc. C-136493). New additions at this level include *Palmatolepis winchelli*, *P. foliacea*, *P.* sp. cf. *P. foliacea*, *P.* sp. aff. *P. rhenana*, *Polygnathus* sp. aff. *P. angustidiscus*, *P. brevis* sensu Szulczewski (1972), and *P. aspelundi*. Carry-overs from lower levels include *Icriodus symmetricus*, *Palmatolepis kireevae*, *P. unicornis*, *Ancyrodella nodosa*, *Ozarkodina postera*, *Polygnathus decorosus*, and *P. evidens*. This fauna is assigned to Klapper's (1989a) Zone [MN]12, or Klapper and Lane's (1989) Fauna Interval [A]7. In terms of Ziegler's (1962, 1971) standard zonation, this is equivalent to the Lower *gigas* Zone, of late Frasnian age.

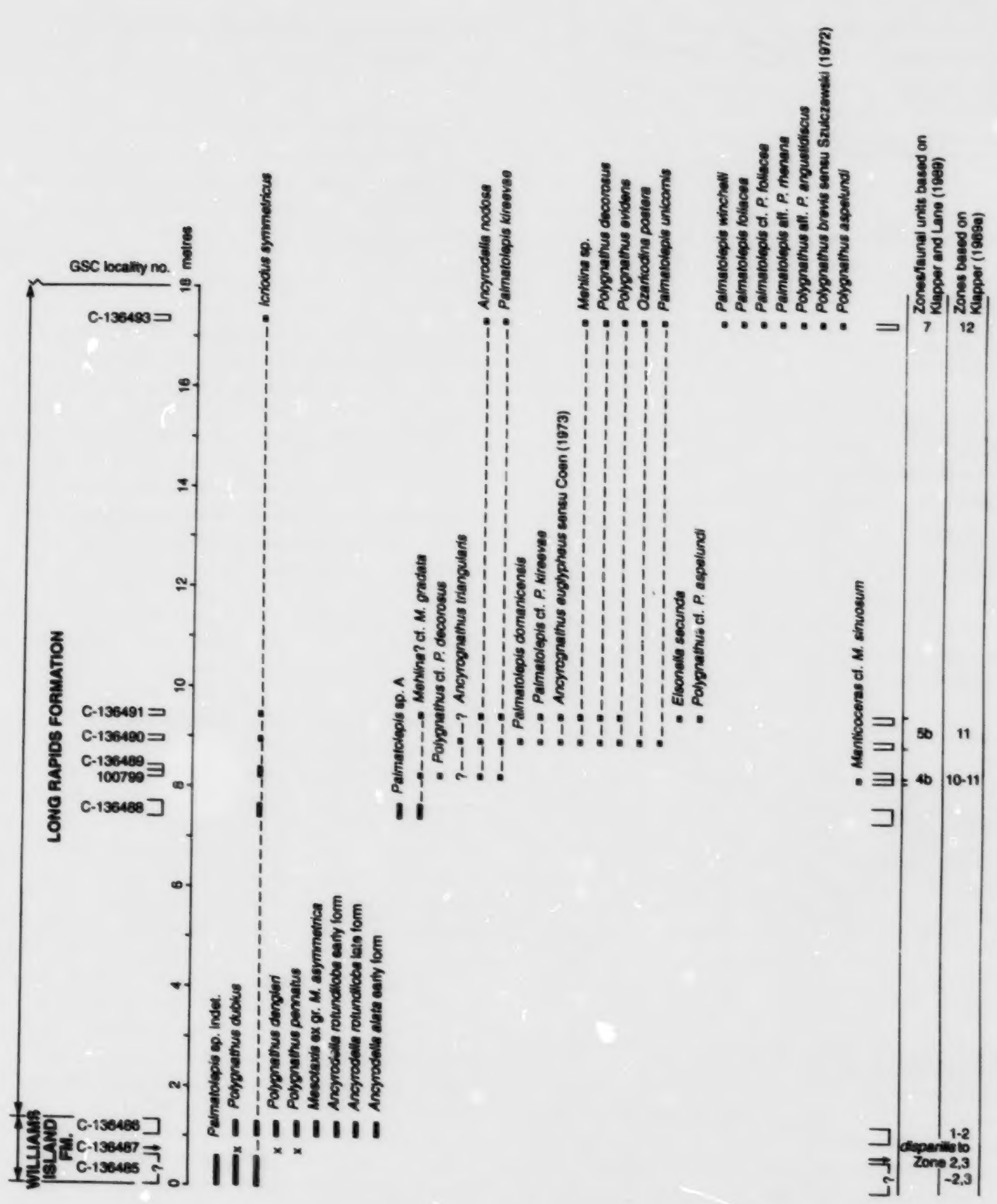


Figure 7. *Distribution and zonation of conodonts from uppermost Williams Island Formation and lower Long Rapids Formation at Abitibi River. Correlations with Klapper's (1989a) zonation at the Montagne Noire section, France, and with that of Klapper and Lane (1989) for the southern Rocky Mountains, Alberta, are shown on the right.* ***Manticoceras sp. cf. M. sinuosum (Hall)*** *occurs at GSC loc. 100799.*

(Note that GSC loc. C-136485 actually covers the entire 1.3 m of the uppermost Williams Island Formation, but because most of the collection from the locality is from the lower part of this interval, it is questionably shown as being from the lower part of the interval here.)

Formation		WILLIAMS ISLAND			LONG RAPIDS					
Sample weight (kg)		3.4	0.1	3.6	2.7	3.7	2.1	3.3	3.0	3.4
Metres above base of section		0.7 - 0.7	0.0 - 1.3	1.0 - 1.3	7.4 - 7.7	8.2 - 8.3	8.3 - 8.4	8.9 - 9.0	9.4 - 9.5	17.3 - 17.4
GSC locality number		C-136487	C-136485	C-136486	C-136488	100799	C-136489	C-136490	C-136491	C-136493
P. dubius	Pa	8	9	26						
P. dengleri	Pa	6		7						
P. pennatus	Pa	3		29						
Belodella sp.		1	1			2		3	4/?5	55
Pa. sp. indet.	Pa		2							
I. symmetricus	I		3	3		33	1	4	6	11
	S2a					3				
	S2b					2				
An. rotundiloba early	Pa			1/?3						
An. rotundiloba late	Pa			1/?2						
An. alata early	Pa			2						
Mesotaxis ex gr. *M. asymmetrica*	Pa			4						
An. sp.	Pb				1					
Pa. sp. A	Pa				3					
	Pb				1					
M.? cf. *M. gradata*	Pa				17	168			1	
P. sp.	Pa				3		2			9
Oulodus? sp.	Pb					2				
	M					1				
	Sa					1				
	Sb					1				
	Sc					5				
A. triangularis	Pa					?10		1/?5	?5	
An. nodosa	Pa					12		30	10	1
Pa. kireevae	Pa					48		19cf 6	27cf 11	14
	Pb					46		1	2	
	M							1	2	2
P. decorosus	Pa					cf 62		70	72	104
Pa. sp.	Pa						3			3
Pa. domanicensis	Pa							3		
A. euglypheus sensu Coen (1973)	Pa							1	2 /?1	
M. sp.	Pa							1	3	10
O. postera	Pa							1		4
	Pb									3
Pa. unicornis	Pa							3		2
P. evidens	Pa							108	91	57
Elsonella secunda	Sc								4	
	Pb								5	
	M?								3	
P. aspelundi	Pa								?6	1
A. sp.	Pa									1
Pa. foliacea	Pa									11cf 38
Pa. aff. *Pa. rhenana*	Pa									8
Pa. winchelli	Pa									42
	Pb									5
	M									2
P. aff *P. angustidiscus*	Pa									3
P. brevis sensu Szulczewski (1972)	Pa									1
Unassigned elements:										
	Pa			1	2			?2	5	12
	Pb	2		18	7	76	1	34	45	93
Pb ("*Nothognathella*")									27	120
	M	6		12	13	148		24	49	254
	Sa	1		1		29		13	9	64
	Sb	1		2		27		3	6	54
	Sc			3		58	1	19	28	116
	Sd					13		1	1	2
Simple cones					2				3	8

Figure 8. Distribution and number of conodont species in the uppermost Williams Island Formation and lower Long Rapids Formation at Abitibi River. P., Polygnathus; Pa., Palmatolepis; I., Icriodus; An., Ancyrodella; A., Ancyrognathus; M., Mehlina; O., Ozarkodina.

Correlations and affinities of conodonts from Abitibi River

Zones [MN]1 and [MN]2 of Klapper (1989a), established in the Montagne Noire of southern France, have been recognized in the highest part of the Williams Island Formation, in what is regarded as a mixed or reworked fauna. In northeastern Alberta, Zones [MN]1 and [MN]2 occur in the Christina Member and Moberly Member, respectively, of the Waterways Formation (Uyeno, 1974; Uyeno *in* Norris and Uyeno, 1981). In western New York, Zone [MN]1 has been recognized within the Penn Yann Shale Member of the Genesee Formation, and Zone [MN]2 in the Genundewa Limestone Member of the Genesee Formation (Kirchgasser et al., 1986; Klapper, 1989a).

There is a large faunal and sampling gap between the highest beds of the Williams Island Formation and the lowest conodont sample in the Long Rapids Formation. Conodonts of Zone [A]4b (of Klapper and Lane, 1989) occur at 6.9 to 7.0 m above the base of the Long Rapids Formation, together with *Manticoceras* sp. cf. *M. sinuosum* (GSC loc. 100799). In the southern Rocky Mountains, Zone [A]4b has been reported from the upper Perdrix Formation (Klapper and Lane, 1989). These authors (ibid.) further suggested correlation of Zone [A]4 with the upper Hay River Formation and Twin Falls Formation, based on the study by Klapper and Lane (1985). In New York, *M. sinuosum* occurs in the Cashaqua Shale of the Sonyea Group (Kirchgasser and House, 1981, p. 43, 48). The lowermost part of the Cashaqua Shale contains conodonts of Zone [MN]5 of Klapper (1989a, p. 451, 453), but the higher beds are assignable to the *A. triangularis* Zone (Klapper, 1981, p. 64).

Zone [A]5b spans the Perdrix-Mount Hawk formational boundary in Alberta (Klapper and Lane, 1989). According to these authors (op. cit., p. 472), the zone is correlative with the fauna near the top of the Twin Falls Formation on Hay River.

Faunal Interval [A]7, which is correlative with Zone [MN]12 (Klapper and Lane, 1989, p. 473), occurs in the highest sample (GSC loc. C-136493) examined in this study. Conodonts of Faunal Interval [A]7 have been reported from the upper parts of the Mount Hawk Formation in Alberta. This faunal interval is correlated with faunas from the upper Fort Simpson Shale and Jean-Marie Member of the Redknife Formation (Klapper and Lane, 1989).

Two species, formerly described by Klapper and Lane (1985) from southwestern District of Mackenzie, are present in the Long Rapids Formation. They are *Polygnathus evidens*, reported from the Hay River and Twin Falls formations, and *Ozarkodina postera*, from the Hay River, Twin Falls, Fort Simpson, and Redknife (Jean-Marie Member) formations. Two additional species, which are similar, if not identical, to those described by Klapper and Lane (1985), include *Mehlina* sp. and *Polygnathus* sp. aff. *P. angustidiscus*. The latter form was reported from the Hay River Formation.

Polygnathus evidens and *Ozarkodina postera* were also reported from the southern Rocky Mountains by Klapper and Lane (1989): *P. evidens* from the Perdrix Formation (Zones [A]4a to [A]5b) at Luscar Mountain, and *O. postera* from the Perdrix, Mount Hawk, and Ronde formations (Zone [A]5a to Faunal Interval [A]7-8) at Luscar Mountain, and at Mount Haultain, from the Perdrix and Mount Hawk formations (Zone [A]4b to Faunal Interval [A]7-8). Another species that occurs in the Rocky Mountains and in the Abitibi River section is *Ancyrognathus euglypheus* sensu Coen (1973), which was reported from the Perdrix Formation (Zone [A]4a) at Mount Haultain.

The common occurrences of the species mentioned above suggest some faunal affinity with that part of Western Canada. There are several other species in common with Klapper and Lane's (1985, 1989) studies, but they are more widespread and have no particular bearing on affinities.

Conodonts from the Abitibi River section probably have some affinities with those of the Kettle Point Formation in southwestern Ontario (Winder, 1966). (See notes under "Conodont Biofacies", below.)

Conodont biofacies

Six localities are considered herein for biofacies analysis: one from the uppermost Williams Island Formation, and the remainder from the Long Rapids Formation. Following the procedure used by Klapper and Lane (1985), percentages of all Pa and I (platform) elements identifiable at the generic level are given in Table 1. Similarly, only those samples with at least 20 such elements (from the data given in Fig. 8) are taken into consideration. Table 1 also shows the number of species represented in each genus in every sample, because for biofacies analysis these figures may be as important as the relative abundance (percentage) of the genera present.

The highest Williams Island sample (from GSC loc. C-136486) consists predominantly (79%) of *Polygnathus* (*P. pennatus*, *P. dubius*, and *P. dengleri*, in order of abundance). *Ancyrodella*, *Mesotaxis*, and *Icriodus* constitute 12, 5 and 4 per cent, respectively, of the remaining platform elements. The fauna is representative of the *Polygnathus* biofacies, as described by Klapper and Lane (1985), although some caution should be used because the collection is probably a reworked fauna, as mentioned elsewhere.

Within the Long Rapids Formation, the percentage of *Polygnathus* increases stratigraphically upward before decreasing slightly in the highest sample. The lowest sample (from GSC loc. C-136488) has 71 per cent of *Mehlina*?, and 13 per cent each of *Polygnathus* and *Palmatolepis*. In the beds associated with *Manticoceras* sp. cf. *M. sinuosum* (at GSC loc. 100799), *Mehlina*? is still prominent at 50 per cent, with *Polygnathus*, *Palmatolepis*, and *Icriodus* at 19, 14, and 10 per cent, respectively. In succeeding samples (from GSC locs. C-136490, C-136491, and C-136493), *Polygnathus* again predominates and essentially replaces *Mehlina*?, although *Palmatolepis* and, in material from GSC loc. C-136490, *Ancyrodella*, are significantly abundant.

It is difficult to assign the Long Rapids conodonts to any specific biofacies. In the lowest two samples (from GSC locs. C-136488 and 100799), the biofacies may be similar to that dominated by *Pandorinellina insita*, recorded earlier by Sandberg and Poole (1977, p. 149), because *Mehlina* is morphologically similar to the *P. insita*. *Palmatolepis* and *Polygnathus* are represented by a single species in each of these samples (Table 1).

In collections from the remainder of the Long Rapids Formation (from GSC locs. C-136490, C-136491, and C-136493), *Polygnathus* still has the greatest role, but is only represented by approximately the same number of species as *Palmatolepis* (Table 1). Also *Ancyrodella* and, to a lesser extent, *Ancyrognathus*, are present. In their study of conodonts from southwestern District of Mackenzie, Klapper and Lane (1985, p. 915) cite four samples that have 10 per cent or more of *Palmatolepis* (or *Mesotaxis*), but none of them was associated with *Ancyrodella* or *Ancyrognathus*. Using the ecological model of Seddon and Sweet (1971), Mouravieff (1982) suggested that *Ancyrodella* and *Ancyrognathus* occupied shallow water environments, whereas *Palmatolepis* and *Polygnathus asymmetricus* (= *Mesotaxis* as used herein) were present only in deeper waters. Klapper

TABLE 1

Generic composition of conodont faunas in the uppermost Williams Island Formation and lower Long Rapids Formation

GSC loc. number	Total Pa + I	*P.*	*Pa.*	*I.*	*An.*	*A.*	*M.*	*O.*	*Pa. + I.*
Williams Island Formation									
C-136486	78	62–79 **3**	4–5 **1**	3–4 **1**	9–12 **2**				83
Long Rapids Formation									
C-136488	24	3–13 **1**	3–13 **1**		1–1 **1**		17–71 **1**		13
100799	333	62–19 **1**	48–14 **1**	33–10 **1**	12–4 **1**	10–3 **1**	168–50 **1**		29
C-136490	252	178–70 **2**	31–12 **4**	4–2 **1**	30–12 **1**	7–3 **2**	1–<1 **1**	1–<1 **1**	72
C-136491	235	169–72 **3**	38–16 **2**	6–3 **1**	10–4 **1**	8–3 **2**	4–2 **2**		75
C-136493	321	175–55 **6**	119–37 **6**	11–3 **1**	1–<1 **1**	1–<1 **1**	10–3 **1**	4–1 **1**	58

In columns three to nine, the number on the left is the count from Figure 8, the number on the right is the percentage of the total platform elements (rounded to the nearest per cent). The number in column two is the total number of platform elements (Pa + I for *Icriodus*) in samples with a minimum of 20 such elements. The last column is the Pa + I of *Polygnathus* and *Icriodus*.

Numbers in bold indicate the number of species representing each genus.

Abbreviations are as follows:
P., *Polygnathus*; *Pa.*, *Palmatolepis* (+ *Mesotaxis*); *I.*, *Icriodus*; *An.*, *Ancyrodella*;
A., *Ancyrognathus*; *M.*, *Mehlina*; (+ *Mehlina*?); *O.*, *Ozarkodina*.

and Lane (1985) suggested that *Ancyrognathus* was present in both the *Polygnathus* and *Palmatolepis* biofacies. The highest sample (from GSC loc. C-136493) may perhaps be referred to the *Palmatolepis* biofacies. The nominal genus is represented by six species, and constitutes 37 per cent of the total number of platform elements. It should be further noted that in the three highest Long Rapids samples, the polygnathids present are predominantly those with narrow platforms, belonging to *Polygnathus decorosus*, or closely related forms, and *P. evidens*.

Throughout the entire succession studied, only a single species of *Icriodus*, *I. symmetricus*, was identified. Klapper and Lane (1985, p. 918) found this species in both the *Polygnathus* and *Palmatolepis* biofacies.

One species that is notably absent in the Long Rapids collections is *Palmatolepis semichatovae* Ovnatanova. This distinct form is widespread in western and midcontinental North America (Klapper and Lane, 1985, 1989; Day, 1989; Sandberg et al., 1989; Birdbear Formation of subsurface southern Saskatchewan, unpublished collections of TTU). Its apparent absence in the Long Rapids Formation is probably due to differences in biofacies, although it may be an artifact of spacing interval in collecting. There are large gaps in the sampling intervals of the Abitibi River section (Fig. 7). A similar *Palmatolepis* biofacies, characterized by *Palmatolepis* (without *P. semichatovae*), *Ancyrodella*, *Ancyrognathus*, and *Polygnathus* with narrow platforms, was reported from the Frasnian sequence in the Montagne Noire, France (Klapper *in* Klapper and Lane, 1985, p. 915; Klapper, 1989a).

Conodont faunas from the Kettle Point Formation in the subsurface of southwestern Ontario were reported by Winder (1966; conodont identification by Klapper). The lower part of that sequence is approximately correlative with the Abitibi River section. The faunas are dominated by *Palmatolepis*. Other components include polygnathids with narrow platforms, belonging to *Polygnathus decorosus*, as well as *Ancyrognathus triangularis*.

The significance of the proportion of *Polygnathus* to *Palmatolepis* in terms of water depth remains obscure, although the general consensus appears to be that the higher the *Palmatolepis* ratio, the more likely were "deep" water conditions. This may imply a uniform to even slightly decreasing water depth during the deposition of the lowest part of the Long Rapids Formation, followed by a slight deepening in the highest part of the interval studied. The highest sample (from GSC loc. C-136493) is dated as the Lower *gigas* Zone within which, according to Johnson et al. (1985, 1986), a deepening event, identified as IId, occurred.

Also remaining obscure is the significance of the preponderance of *Mehlina*? at GSC locs. C-136488 and 100799. If comparison with the *Pandorinellina insita* biofacies is correct, a relatively shallow water, nearshore environment may be indicated.

In terms of conodont biofacies concepts of Sandberg (1976; see also Sandberg and Ziegler, 1979; Sandberg et al., 1988; Sandberg et al., 1989), the highest collection from the Williams Island Formation (GSC loc. C-136486) may be assigned to the polygnathid-ancyrodellid biofacies. *Ancyrodella*, according to Sandberg et al. (1989, p. 201), had its optimum habitat in neritic settings in the middle belts occupied by the early Frasnian polygnathid-ancyrodellid and polygnathid biofacies.

SYSTEMATIC PALEONTOLOGY

All specimens described and illustrated in this report that were collected by members of the Royal Ontario Museum and the Ontario Geological Survey have been curated by the Royal Ontario Museum, 100 Queen's Park, Toronto, Ontario M5S 2C6, and are assigned ROM type numbers. Fossils collected by officers of the Geological Survey of Canada are assigned GSC type numbers and have been curated by the Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario, K1A 0E8. Source beds and locality data are indicated by field and/or GSC locality numbers, which are described in detail in the Locality Register in the Appendix.

The following abbreviations are used: bv, brachial valve; pv, pedicle valve; D, depth; L, length; W, width; est., estimated.

Ia. BRACHIOPODS — A.W. NORRIS

Phylum BRACHIOPODA Duméril, 1806

Class INARTICULATA Huxley, 1869

Order LINGULACEA Waagen, 1885

Superfamily LINGULACEA Menke, 1828

Family LINGULIDAE Menke, 1828

Genus *Lingula* Bruguière, 1797

Type species. [*Lingula anatina* Lamarck, 1801, p. 141; ICZN pend.] [= *Pharetra* Bolton, 1798, p. 159 (type *P. monoculoides*); *Ligula* Cuvier, 1798, p. 435 (nom. null.); *Ligularius* Duméril, 1806, p. 170 (nom. van.); *Lingularius* Schuchert and LeVene, 1929, p. 76 (nom. null.)]

Lingula sp.

Plate 10, figures 16-18; Plate 11, figure 1

Material. Represented by one complete ventral valve; one nearly complete dorsal valve; and seventeen incomplete valves. Specimens were recovered from the residue of a limestone sample etched for conodonts.

Dimensions (mm) and other parameters.

Specimen	H263-1 (pv)	H263-2 (bv)
Type No.	Hypotype ROM 47262	Hypotype ROM 47263
GSC Loc. No.	100799	100799
Length of pv (Lpv)	2.06	—
Length of bv (Lbv)	—	1.96
Width (W)	1.11	1.06
Ratio: L/W	1.86	1.85

Description. An exceedingly small form; longitudinally elliptical in outline; length approximately twice width; posterior margin forms an angle of about 113 degrees; sides slightly convex, nearly parallel; anterior margin broadly rounded; anterolateral extremities broadly rounded.

Ventral valve most convex medianly, highest at about one third of length from beak; umbonal region subcarinate and extending posteriorly to a sharp and narrow beak. Pedicle groove on interior of valve is deep and narrow. No indication of muscle attachment areas.

Dorsal valve in lateral profile has maximum height in umbonal region. Beak region narrowly rounded. Interior features of valve not evident.

Exterior of valves marked by very fine, closely spaced, radial markings, most evident on pedicle valve; and more conspicuous, irregularly spaced, concentric growth lines. All valves exhibit colour markings of concentric bands of transparent shell alternating with bands of cream-coloured shell. The initial parts of both valves are generally transparent. Shell substance is impunctate.

Remarks. This form is distinguishable from *Lingulipora* sp. by its impunctate shell. *Lingula* sp. and *Lingulipora* sp. occur together in the sample in approximately equal numbers; and in morphological features other than punctation, they are closely similar.

Occurrence. GSC locality 100799 (field no. 84SA3; = locality Ab-6) from a greyish green, micritic limestone bed, 0.05 m thick, within dark grey to black shale, 8.2 m above base of section, Long Rapids Formation.

Figured specimens. Hypotype ROM 47262, ventral valve of a young adult individual; and hypotype ROM 47263, dorsal valve of a young adult individual.

Genus *Lingulipora* Girty, 1898, p. 387

Type species. *Lingula* (*Lingulipora*) *williamsonia;* OD.

Lingulipora sp.

Plate 10, figures 19-23; Plate 11, figures 2, 3

Material. Represented by one complete dorsal valve; one complete ventral valve; one incomplete (?)ventral valve; and 19 fragmentary valves. Recovered from the residue of a limestone sample etched for conodonts.

Dimensions (mm) and other parameters.

Specimen	H263a-3 (bv)	H263a-4 (pv)	H263a-5 (?v)
Type No.	Hypotype ROM 47264	Hypotype ROM 47265	Hypotype ROM 47266
GSC Loc. No.	100799	100799	100799
Length of pv (Lpv)	—	1.27	—
Length of bv (Lbv)	2.01 +	—	—
Width (W)	1.38	0.87	1.86
Ratio: L/W	1.46	1.46	—

Description. Shell size very small, maximum length slightly greater than 2 mm; length approximately one and a half times width; posterior margins of two valves form angles of 88 and 136 degrees, suggesting that there are two variant forms, one with a narrowly rounded posterior margin, and the other with a broadly rounded posterior margin.

Dorsal valve in lateral profile has maximum height in umbonal region; beak region slightly raised, broadly angular; posterior margin slightly thickened and flattened; muscle attachment features not preserved.

Both outer and inner surfaces of both valves marked by irregularly spaced concentric growth lines. Umbonal regions of most valves are transparent or translucent, and this is followed by alternating concentric bands of variable width of cream-coloured (?mineralized) and transparent (nonmineralized) bands of shell. Inner layers of valves punctate, the punctae being relatively coarse and widely and irregularly spaced.

Remarks. *Lingulipora* sp. from the Long Rapids Formation of northern Ontario is distinguished from *Lingulipora williamsana* (Girty, 1898, p. 387), the type species of the genus, from the Chattanooga Shale of Virginia, U.S.A., by its much smaller size, and the lack of fine, closely spaced pustules with their long axis parallel to growth lines (Rowell, *in* Moore, 1965, v. 1, p. H263).

Lingulipora sp. from northern Ontario is readily distinguished from *Ligulipora porifera* Cooper and Dutro (1982, p. 33, Pl. 39, figs. 52–56) from the basal Ready Member of the Percha Formation of New Mexico by its much smaller size, its more rounded anterior margin, and by coarse punctae that are all of approximately the same size rather than of two sizes.

Lingulipora sp. has been recorded also by Baliński (1979, p. 26, Pl. 1, figs. 1–3, 11) from throughout the Frasnian of the Dębnik Anticline, southern Poland, but is particularly numerous in the Middle and Upper *asymmetrica* conodont zones, and in the uppermost *gigas* Zone. *Lingulipora* sp. from northern Ontario appears to be closely similar in overall shape and in distribution and size of punctae, but is about one quarter of the maximum size of the form from Poland.

Occurrence. GSC locality 100799 (field no. 84SA3; = locality Ab-6) from a greyish green, micritic limestone bed, 0.05 m thick, within dark grey to black shale, 8.2 m above base of section, Long Rapids Formation.

Figured specimens. Hypotype ROM 47264, brachial valve of a young adult individual; hypotype ROM 47265, pedicle valve of a young adult individual; and hypotype ROM 47266 fragment of valve of a young adult individual.

Order ENTELETIDA Waagen, 1884

Superfamily ENTELETACEA Waagen, 1884

Family ENTELETIDAE Waagen, 1884

Subfamily SCHIZOPHORIINAE Schuchert, 1929

Genus *Schizophoria* W. King, 1850

Type species. Conchyliolithus (*Anomites*) *resupinatus* Martin, 1809, Pl. 49, figs. 13, 14.

Schizophoria sp. cf. *S. athabaskensis* Warren

Plate 1, figures 1-16

1868 *Orthis iowensis* Hall?. Meek, p. 90, Pl. 12, figs. 2a-2h.

1891 *Orthis striatula* Schlotheim. Whiteaves, p. 218 (part).

1944 *Schizophoria athabaskensis* Warren, p. 110, Pl. 1, figs. 2, 3 (syntypes D827 and D828).

1952 *Schizophoria athabaskensis* Warren. Bassett, p. 129, Pl. 1, figs. 15-18.

1956 *Schizophoria athabascensis* Warren and Stelck, Pl. 11, figs. 11-13 (syntypes Dv827 and Dv828).

1983 *Schizophoria athabaskensis* Warren. Norris, p. 10, Pl. 1, figs. 17-26; Pl. 2, figs. 1-17.

Material. Six complete and four incomplete specimens. All but one of the specimens are juvenile forms.

Dimensions (mm) and other parameters.

Specimen	H332-1	H332-2	H332-3	H332-4
Type No.	Hypotype ROM 47267	Hypotype ROM 47268	Hypotype ROM 47269	Hypotype ROM 47270
Locality No.	Ab-"11"	Ab-"11"	Ab-"11"	Ab-"11"
Length of pv (Lpv)	25.3	15.8	12.9	—
Length of bv (Lbv)	26.7	15.1	12.9	—
Width (W)	30.2	17.6	16.4	—
Depth (D)	14.7	7.6	8.1	—
Width of pedicle interarea (Wpi)	10.7	7.5	8.0	—
Depth of sulcus at anterior margin	10.3	3.1	2.2	—
Ratio: W/Lpv	1.19	1.11	1.27	—
Ratio: W/Wpi	2.82	2.35	2.05	—
Costellae in 5 mm, 10 mm from beak	pv 13 bv 19	pv 16 bv 15	pv 17 bv 19	— —
Costellae in 5 mm, 20 mm from beak	pv 13 bv 15	pv — bv —	pv — bv —	— —

Description. Young adult shell is of moderate size for the genus; unequally biconvex, with the brachial valve accounting for two thirds or more of total depth of shell. Transversely subelliptical in outline, shell is wider than long, ratio of width to length of pedicle valve varies from 1.11 to 1.27 amongst figured specimens, greatest width near or anterior of midlength; anterior margin weakly uniplicate in juvenile stages, becoming moderately uniplicate in adult stages; about half of the specimens are slightly indented at medial anterior margin.

Pedicle valve is weakly to moderately convex with highest point between 3.7 to 5.6 mm anterior of beak; reversing curvature anteriorly and laterally at a variable distance from beak, varying from 10.6 to 14.6 mm amongst figured specimens; reversed curvature of flanks slightly concave. A broad, shallow sinus starts at about three quarters of length of valve, and gradually deepens and widens anteriorly to form a broadly rounded, V-shaped lingual extension in the opposite valve; beak prominent; umbo slightly inflated, relatively flat along midline; interarea relatively high, its width varying from about half of width in young stages to about one third of width of shell in adults stages, slightly curved, approaching catacline toward hinge line, apsacline toward apex of beak; delthyrium open, narrowly triangular at the apex, varying between 23 and 26 degrees; posterior rim of pedicle foramen circular and slightly raised.

Brachial valve is very strongly convex, highest point varying from one third to one half of length of valve, lateral flanks sloping steeply, reversing curvature laterally to become slightly concave. Umbo is highly inflated, broadly convex, and commonly extends beyond apex of opposite valve. A barely perceptible sinus is present along the midline in young specimens, and near the anterior margin of older specimens a very weak fold is developed, which is bounded on each side by shallow depressions; on two specimens the anterior median margin of valve is marked by a right-angled bend as a continuation of the tongue of the opposite valve. Beak is small, and strongly inturned. Interarea is broad, much lower than that of opposite valve, strongly arched, and apsacline.

Both valves are ornamented by very fine, radiating, hollow costellae that increase in number anteriorly by bifurcation and intercalation. The costellae are round-crested and are separated by rounded troughs of about equal or greater width. Number of costellae varies from 13 to 19 in 5 mm of arc at 10 mm from beak, and from 13 to 15 in 5 mm of arc at 20 mm from beak. Shell substance is very finely punctate.

Interior of brachial valve (Pl. 1, fig. 16) has stout brachiophores, which are continuous with their supporting plates. The plates are nearly vertical, strongly divergent, and mark the lateral margins of the muscle field. Cardinal process is small, lenticular shaped, slightly elevated above floor of notothyrial cavity, and marked with irregular "herring-bone"-like striations. Low elevations are present on each side of anterior two thirds of the cardinal process. Muscle area is indistinct; and pallial sinuses are prominent.

Remarks. This form most closely resembles *Schizophoria athabaskensis* Warren (1944), which occurs typically in the Calumet Member of the Waterways Formation of northeastern Alberta (Norris, 1983, p. 11, Fig. 4). The largest specimen from the Abitibi River is only about two thirds of the maximum size attained by specimens from northeastern Alberta. Other minor differences in forms from the two areas include the variably developed, dorsally deflected, anterior median margin, and a less distinct muscle area in the dorsal valve of Abitibi River specimens.

Occurrence. Locality Ab-"11" (=GSC loc. C-136485); green, "clay-shale" bed, 1.3 m thick, uppermost Williams Island Formation; east bank of Abitibi River, immediately south of Williams Island.

Figured specimens. Hypotype ROM 47267, a young adult specimen; hypotype ROM 47268, a juvenile specimen; hypotype ROM 47269, a juvenile specimen; and hypotype ROM 47270, an incomplete brachial valve of a juvenile specimen.

Superfamily STROPHOMENACEA King, 1846

Family STROPHEODONTIDAE Caster, 1939

Subfamily STROPHEODONTINAE Caster, 1939

Genus *Strophodonta* Hall, 1850

Type species. *Leptaena demissa* Conrad, 1842, p. 258 [=*Stropheodonta* Hall, 1852, p. 63 (nam. van.)].

Subgenus *Strophodonta* (*Strophodonta*) Hall, 1852 emend.

Type species. *Leptaena demissa* Conrad (see above).

Strophodonta (*Strophodonta*) *abitibiensis* Norris n. sp.

Plate 1, figures 17-33

Etymology. The trivial name is after the Abitibi River, which drains the southern part of the Moose River Basin in northern Ontario (see Sanford and Norris, 1975, Fig. 3).

Diagnosis. *Strophodonta* (*Strophodonta*) with a moderately thick, concavo-convex lateral profile, a subquadrangular outline, cardinal angles variably extended; both valves ornamented with radiating, angular-crested, uneven costae of medium strength.

Material. One complete shell, one brachial valve, five pedicle valves, and three incomplete shells.

Dimensions (mm) and other parameters.

Specimen	H395-1	H395-2	H395-3	H395-4
Type No.	Holotype ROM 47271	Paratype ROM 47272	Paratype ROM 47273	Paratype ROM 47274
Locality No.	Ab-"11"	Ab-"11"	Ab-"11"	Ab-"11"
Length of pv (Lpv)	18.3	14.3	—	15.8
Length of bv (Lbv)	16.1	—	13.3	—
Width at hinge line (Whl)	29.9	18.3	19.1	19.9

Width, main body of shell (Wb)	22.7	17.8	18.6	19.0
Depth of shell (D)	9.1	6.7?	—	7.1
Ratio: Whl/Lpv	1.63	1.28	1.44	1.26
Ratio: Wb/Lpv	1.24	1.24	1.40	1.20
Costae in 5 mm, 10 mm from beak	pv 9 bv 8	pv 8 bv —	pv — bv 8 est.	pv 9 bv —

Description. Medium sized, shell moderately thick, concavo-convex, subquadrangular in outline, cardinal angles variably extended, anterolateral margins rounded, slight indentations immediately anterior of cardinal extensions, wider than long with greatest width along the hinge line.

Pedicle valve generally moderately convex, two of the ten specimens show weak convexity, highest along the midline; flanks curve evenly to the lateral and anterior margins, some valves with pronounced indentations separating the flanks from the mucronate cardinal extremities. Beak is small, rounded, and slightly extended. Ventral interarea low, highest beneath the beak and evenly decreasing in height toward the cardinal extremities, slightly curved, apsacline toward hinge line, and anacline toward beak. Interarea is covered by closely spaced, longitudinally oriented denticles that become less distinct and disappear toward the hinge line and cardinal extremities. Delthyrium is triangular, and covered by a smooth pseudodeltidium.

Brachial valve is weakly concave, deepest along midline at or posterior to midlength, curvature gentle toward lateral and anterior margins, more sharply upturned along cardinal margin; areas of cardinal extensions are sharply depressed. Beak is small and inconspicuous. Dorsal interarea is very low, slightly higher adjacent to beak, oriented almost perpendicular to plane of commissure (catacline); covered by faint, closely spaced, longitudinal denticulations.

Both valves ornamented by radiating, angular-crested, uneven costae, which increase in number anteriorly mainly by intercalation but also by bifurcation and trifurcation, a pattern which is best referred to as "unequally parvicostellate". Very fine, weak, longitudinal striations are evident on some costae. Troughs separating costae are of equal or greater width. Concentration of costae at 10 mm from apex of valves is 8 to 9 in 5 mm of arc amongst illustrated specimens. Coarse, concentric growth lines are widely and irregularly spaced.

Interior of pedicle valve has a stout ventral process that is continuous with the pseudodeltidium and projects anteriorly to articulate with a central depression of the cardinal process of the opposite valve; on the floor of the valve this structure is continuous with two arcuate ridges that laterally enclose the adductor scars; large pits for the reception of the cardinal process lobes lie on each side. Adductor muscle field has two posterior, elongate scars separated by a depression, and a lenticular anterior scar marked longitudinally by a faint, narrow depression, which is partly enclosed laterally by the anterior ends of the posterior adductors. Diductor muscle field consists of two subflabellate, radially fluted scars that extend anterolaterally from the adductors to about midlength of valve. Inner surface of valve outside the muscle fields is marked by irregularly distributed pustules.

Interior of brachial valve has a stout cardinal process and two lobes directed posteriorly at an angle of 45 degrees to the plane of the commissure. Two shallow pits behind the cardinal process receive blunt projections from the dental process. The muscle field is markedly elevated above the floor of the valve; it is divided anteriorly by a broad median ridge that terminates near peripheral rim; posterior adductors are coarsely reniform areas bounding the elliptical anterior adductors laterally. Between the muscle field and the peripheral rim is a depressed area marked by irregularly distributed pustules. Peripheral rim on interior lateral and anterior sides of valve is about 3 mm wide, up to 4 mm high, forms an angle of about 120 degrees with commissure, and is radially fluted. A narrow area flanking the hinge margin and cardinal process on the inner surface of the valve is denticulated.

Remarks. The shape of the shell and the size of the costae of this form bear some resemblance to some specimens of "*Stropheodonta*" *equicostata* Swallow described and illustrated by Branson (1922, p. 79, 80, Pl. 11, fig. 6, Pl. 12, figs. 9–17) from the Snyder Creek Shale of Missouri. The closest similarity is to the wider variants of the species, particularly the two specimens illustrated in Plate 12, figures 16, 17 of Branson (1922). *Strophodonta* (*Strophodonta*) *abitibiensis* n. sp. is distinguished from the Missouri species by its greater width to length ratio, its less rotund and less extended ventral umbo, its less pronounced cardinal extremities, and its less extended anterior margin.

Of the numerous strophodontids occurring in the Waterways Formation of northeastern Alberta, the species showing the closest similarity to the form from northern Ontario is *Strophodonta* (*S.*) *albertensis*

Norris (1983, p. 14, 15, Pl. 3, figs. 30-33, Pl. 4, figs. 1-13). *Strophodonta* (*S.*) *abitibiensis* n. sp. is distinguished from the Alberta species by its more pronounced cardinal extremities, greater convexity of the ventral valve, slightly coarser costae, and smaller size at maturity.

In the development of extended cardinal angles, *Strophodonta* (*S.*) *abitibiensis* n. sp. is somewhat similar to *Stropheodonta littletonensis* Stainbrook (1938b, p. 253, 254, Pl. 34, figs. 10, 11, 14) from the *waterlooensis* beds of the Rapid Member of the Cedar Valley Limestone of Iowa. However, *S.* (*S.*) *abitibiensis* n. sp. differs from the Iowa species in its much smaller size at maturity, in being proportionately thicker, and in having more pronounced indentations separating the cardinal angles from the lateral margins of the shell.

Occurrence. Locality Ab-"11" (=GSC loc. C-136485); green, "clay-shale" bed, 1.3 m thick, uppermost Williams Island Formation; east bank of Abitibi River, immediately south of Williams Island.

Figured specimens. Holotype ROM 47271, a complete, large, adult specimen with extended cardinal angles; paratype ROM 47272, a pedicle valve of a small, rotund adult individual; paratype ROM 47273, a brachial valve of a small, adult individual with a high peripheral rim on interior of valve; paratype ROM 47274, a brachial valve of a small, adult individual.

Family STROPHEODONTIDAE Caster, 1939

Subfamily LEPTOSTOPHIINAE Caster, 1939

Genus *Nervostrophia* Caster, 1939, p. 79

Type species. Strophomena nervosa Hall, 1843, p. 266; OD. [=*Sulcatostrophia* Caster, 1939, p. 81 (type, *Leptostrophia camerata* Fenton and Fenton, 1924, p. 96); *Pseudodouvillina* Stainbrook, 1945, p. 26 (type *P. euglyphaea*)].

Nervostrophia ralla Norris n. sp.

Plate 1, figures 34-37; Plate 2, figures 1-7

Diagnosis. Nervostrophia of small, mature size for the genus, with an exceedingly thin and flat lateral profile; shell is delicate and fragile; parvicostellate ornamentation on the pedicle valve is more conspicuous than that on the brachial valve.

Material. Represented by one complete shell, one pedicle valve, and four incomplete shells.

Etymology. Latin, *rallus*, thin; referring to the very thin, relatively flat shell.

Dimensions (mm) and other parameters.

Specimen	H398-1	H398-2	H398-3	H398-4
Type No.	Paratype ROM 47275	Holotype ROM 47276	Paratype ROM 47277	Paratype ROM 47278
Locality No.	Ab-"11"	Ab-"11"	Ab-"11"	Ab-"11"
Length of pv (Lpv)	11.1	10.3	10.0	9.4
Length of bv (Lbv)	—	9.4	—	9.1
Width (W)	12.7	13.6	14.4 (est.)	14.0 (est.)
Ratio: W/Lpv	1.14	1.32	1.44	1.49
Costae in 2 mm, 5 mm from beak	pv 13 bv —	pv — bv 19	pv 14 bv —	pv 14 bv 23

Description. Shell of small size for the genus, very thin and flat, wider than long, with ratio of width to length of pedicle valve varying from 1.14 to 1.49 amongst figured specimens, greatest width along or slightly anterior of hinge line, subquadrate in outline, with rounded anterior lateral margins, two specimens with slightly extended cardinal extremities, and with weak indentations separating cardinal extremities from lateral margins.

Pedicle valve flattened, only slightly convex, highest in the umbonal region. Beak small, and very slightly extended. Interarea low, about 0.5 mm high beneath the beak, and of nearly the same height throughout, flat and apsacline. Pseudodeltidium completely covering delthyrium, narrow, triangular, and strongly arched medianly.

Brachial valve very gently concave, deepest along midline at about one third of length from beak, flattened anterolaterally. Interarea very low, about 0.2 mm beneath beak, and of nearly the same height throughout, flat, hypercline. Beak indistinguishable; chilidium strongly convex, very small, covering notothyrium.

Surface of both valves marked by numerous radial costae and costellae, which are somewhat irregular in size and development and which increase in number by intercalation. On pedicle valve, costae are relatively coarse, erect, irregular, and discontinuous, and generally increase in strength anteriorly. Intercostal spaces are occupied by five to eight costellae at anterior margin. The costellae are more continuous and regular than the costae. Costae on the brachial valve are finer than those on the pedicle valve, are more gently convex, and only a few display a tendency toward interruption and swelling. Intercostal spaces tend to be wider on the brachial valve than on pedicle valve and to have more costellae. The entire surface of both valves is marked by numerous, closely spaced, concentric growth lines, producing a rugose appearance where they cross the costae and costellae. Occasional growth lines are prominent and lamellose.

Edges of valves are thin and fragile, and most of them have ragged and indented edges. Shell substance has fine, closely spaced pseudopunctae.

Interior of pedicle valve has a denticulate hinge area, and denticles decrease slightly in size laterally. Pits for reception of cardinal process of opposite valve are small but deep. Ventral process strong, connected to a weak median ridge along floor of valve, which divides anteriorly into tapering ridges. Muscle area bounded laterally by strong, diverging ridges; in specimen at hand (Pl. 1, figs. 36, 37) one of these ridges has been strongly deformed laterally. Interior of valve outside muscle area marked by small, closely spaced, radiating pustules; the coarser parvicostellae (costae) are vaguely impressed on the interior of the valve.

Interior of brachial valve not seen.

Discussion. On the basis of thin, fragile shells, shape outline, fine parvicostellate ornamentation, slightly extended hinge margin, and muscle pattern in interior of pedicle valve, *Nervostrophia ralla* n. sp. is closely similar to *Leptostrophia fragilis* Hall, as described and illustrated by Stainbrook (1943a, p. 40, Pl. 6, figs. 5–7) from the "*Atrypa*" *bellula* Zone in the Rapid Member of the Cedar Valley Limestone of Iowa and Illinois. *Nervostrophia ralla* n. sp. is distinguished from the Cedar Valley species by its smaller size at maturity, its slightly coarser and more pronounced parvicostellate ornamentation, a smaller and shorter muscle pattern in the pedicle valve, and generally greater width to length ratio.

Another closely similar species is *Nervostrophia plana* Cooper and Dutro (1982, p. 48, Pl. 6, figs. 1–6) from the Oñate Formation of New Mexico. However, *N. ralla* n. sp. is much smaller at maturity, has less extended cardinal extremities, and has a differently shaped muscle pattern in the interior of the pedicle valve.

Nervostrophia tulliensis (H.S. Williams, 1890, Pl. 12, figs. 1–4; A. Williams, 1953a, Pl. 10, figs. 5, 8) present in the Tully Formation of New York State appears to be closely comparable in size, shape, and parvicostellate ornamentation. *Nervostrophia ralla* n. sp. differs from the Tully species by its smaller size at maturity, greater width to length ratio, less extended cardinal extremities, and more pronounced indentations separating the cardinal extremities from the lateral margins of the shell.

Occurrence. Locality Ab-"11" (=GSC loc. C-136485); green, "clay-shale" bed, 1.3 m thick, uppermost Williams Island Formation, east bank of Abitibi River, immediately south of Williams Island.

Figured specimens. Paratype ROM 47275, pedicle valve of an elongate adult shell; holotype ROM 47276, an adult shell with a smaller specimen attached to and partly covering pedicle valve; paratype ROM 47277, a young adult shell attached to ROM 47276 and showing exterior of pedicle valve; and paratype ROM 47278, an incomplete, wide, adult shell.

Superfamily STROPHALOSIACEA Schuchert, 1913

Family STROPHALOSIIDAE Schuchert, 1913

Subfamily STROPHALOSIINAE Schuchert, 1913

Genus *Eostrophalosia* Stainbrook, 1943, p. 58.

Type species. *Strophalosia rockfordensis* Hall and Clarke, 1893, p. 316; OD.

Eostrophalosia parksi Norris n. sp.

Plate 2, figures 8–29, Figure 9

Diagnosis. *Eostrophalosia* with widely spaced, coarse spines on pedicle valve, conspicuous interareas on both valves, and tiny, widely spaced spines on brachial valve, which may be missing on some specimens.

Material. Eleven complete or almost complete shells.

Etymology. Named after the late Dr. W.A. Parks of the University of Toronto, who was one of the first to describe Devonian fossils from the Moose River Basin of northern Ontario.

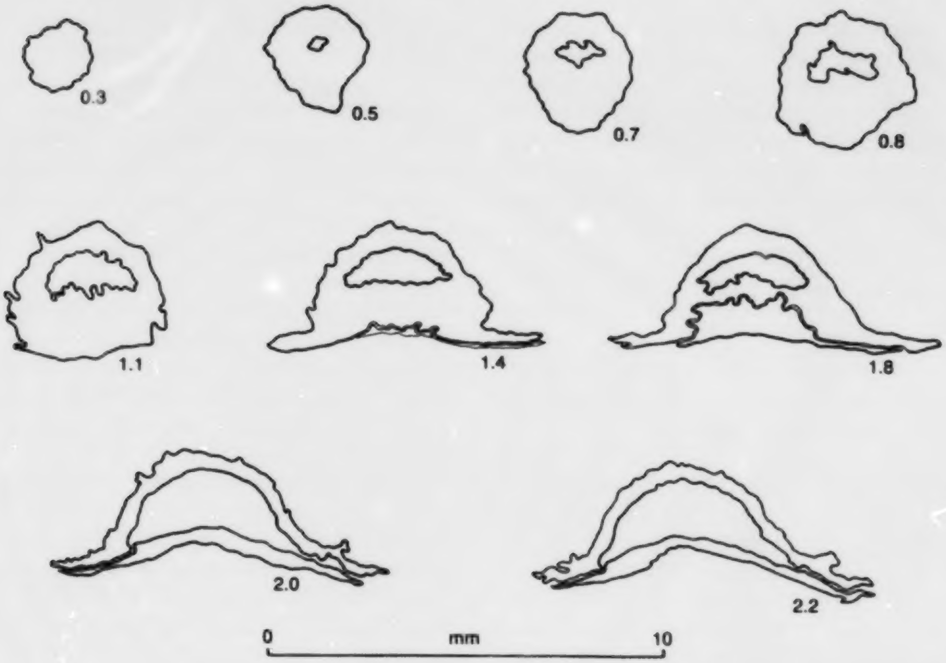


*Figure 9. Transverse serial sections of a specimen of **Eostrophalosia parksi** Norris n. sp. Distances are in millimetres foward from the crest of the pedicle umbo. Paratype ROM 47284. Locality Ab-"11".*

Dimensions (mm) and other parameters.

Specimen	H450-1	H450-2	H450-3	H450-4	H450-5*	H450-6*
Type No.	Paratype ROM 47279	Holotype ROM 47280	Paratype ROM 47281	Paratype ROM 47282	Paratype ROM 47283	Paratype ROM 47284
Locality No.	Ab-"11"	Ab-"11"	Ab-"11"	Ab-"11"	Ab-"11"	Ab-"11"
Length of pv (Lpv)	11.6	10.5	12.1	8.4	8.3	11.0
Length of bv (Lbv)	9.6	8.8	9.9	6.9	7.1	9.3
Width (W)	5.6	13.2	12.9	10.2	10.1	11.1
Depth (D)	6.3	6.0	6.6	3.8	4.0	4.8
Ratio: W/Lpv	1.34	1.26	1.07	1.21	1.22	1.01

*Specimens serially sectioned.

Description. Shell intermediate in size for the genus; semicircular to subcircular in outline; concavo-convex lateral profile; shell wider than long with greatest width between one quarter and one third of length from pedicle umbo.

Pedicle valve strongly convex, highest along midline about midlength, posteriorly recurved at and near beak, flattened at the cardinal angles. Umbo highly inflated and extended beyond the hinge line. Beak small and incurving; some specimens marked by a circular cicatrix of attachment. Interarea low, highest beneath beak, decreasing in height laterally, sometimes diminishing to a line of junction before reaching cardinal extremities; slightly incurved, and anacline. Delthyrium triangular-shaped, open in some specimens, and in other specimens partly covered with a pseudodeltidium, enclosing cardinal process of opposite valve.

Brachial valve moderately concave, most deeply depressed in the umbonal region, sharply elevated and flattened in posterolateral areas of valve, evenly concave toward anterior margin; beak area elevated, elongate and oval. Interarea very low, decreasing laterally in height to a line of junction with opposite valve, and hypercline. Chilidium V-shaped, slightly elevated above level of interarea, marking position of cardinal process.

Exterior of pedicle valve marked by rough, irregular, concentric rugae, which are commonly extended as thin, fragile, short, irregular lamellae.

Spines are scattered over the valve in a roughly concentric arrangement, spine bases of each concentric arc are offset from adjacent arcs; spines emanate from short, rounded, radial ridges; the radially oriented spines are smooth, straight, hollow, recumbent, and probably exceeded 3 mm in length; along and near the posterior margin they are smaller, semierect and directed posterolaterally.

Exterior of brachial valve marked by irregular concentric rugae. Some specimens also display fragile, irregular, concentric lamellae. Spines very tiny, widely spaced, and almost completely absent on some specimens.

Interior of pedicle and brachial valves not seen.

Remarks. The main features of the genus *Eostrophalosia* have been discussed and summarized by Muir-Wood and Cooper (1960, p. 77, 78) and Stainbrook (1943a, 1945). These features include small size of shell, productiform shape, the presence of interareas in each valve, cicatrix of attachment on pedicle valve umbo, and presence of spines on each valve. All of the above features are variably present in the species at hand, with the possible exception of spines on the brachial valve, which may be absent or weakly developed on some specimens.

Comparison. *Eostrophalosia parksi* n. sp. is distinguished from *E. pedderi* Crickmay (1963, p. 17, Pl. 5, figs. 10–15, Pl. 12, figs. 6–12) (see also Norris, 1983, p. 22, 23, Pl. 6, figs. 21–32) from the lower part of the Moberly Member of the Waterways Formation of northeastern Alberta by its smaller size at maturity, more widely spaced spines on the pedicle valve, and the much smaller and more widely spaced spines on the brachial valve.

Eostrophalosia parksi n. sp. is closely comparable to, but differs from, *E. rockfordensis* (Hall and Clarke, 1893; *in* Stainbrook, 1943a, p. 58, Pl. 7, fig. 50), the type species of the genus from the Cerro Gordo Member of the Hackberry Formation of Iowa, in the following features: it is slightly smaller at maturity, it has a narrower and more inflated pedicle umbo, and fewer, more widely spaced and smaller spines on the brachial valve.

Eostrophalosia parksi n. sp. is distinguished from *E. callawayensis* (Swallow) as described and illustrated by Branson (1922, p. 85, 86, Pl. 11, figs. 10, 16, Pl. 15, figs. 10, 11, 13, 14; 1944, Pl. 23, figs. 18, 19) from the Snyder Creek Shale, Callaway County, Missouri, by its much smaller size at maturity, and more conspicuous development of interareas on both valves.

Eostrophalosia parksi n. sp. is distinguished from *E. littletonensis* (Stainbrook, 1943a, p. 58, Pl. 7, figs. 32–37) from the *waterlooensis* Zone of the Cedar Valley Limestone of Iowa by its larger size at maturity, development of spines on the brachial valve, which are possibly not present on *E. littletonensis*, and more conspicuous interareas on both valves.

Another comparable species is *Eostrophalosia independensis* (Stainbrook, 1945, p. 38, 39, Pl. 3, figs. 45–47) from the Independence Shale of Iowa. *Eostrophalosia parksi* n. sp. is differentiated from the Iowa species by its larger size at maturity, its smaller cicatrix of attachment on the pedicle valve, and by having far fewer and more widely spaced spines on the brachial valve.

Occurrence. Locality Ab-"11" (=GSC loc. C-136485); green, "clay-shale" bed, 1.3 m thick, uppermost Williams Island Formation; east bank of Abitibi River, immediately south of Williams Island.

Figured and/or measured specimens. Paratype ROM 47279, a large, broad, adult individual; holotype ROM 47280, a nearly complete, adult individual of intermediate size and shape; paratype ROM 47281, an elongate, adult individual; paratype ROM 47282, a young adult individual; paratype ROM 47283, a young adult shell (serially sectioned); paratype ROM 47284, a circular adult shell (serially sectioned).

The following description is by A.W. Norris, with contributions by P. Sartenaer.

Superfamily RHYNCHONELLACEA Gray, 1848

Family UNCINULIDAE Rzhonsnitskaya, 1956

Subfamily HYPOTHYRIDININAE Rzhonsnitskaya, 1956

Genus *Hypothyridina* Buckman, 1906, p. 323

Type species. [pro *Hypothyris* Phillips, 1841, p. 55 (=King, 1846, p. 28) (*non* Hübner, 1821)] [*Atrypa cuboides* Sowerby, 1840, Pl. 56, fig. 24; OD King].

Hypothyridina? sp. A

Plate 10, figures 1–6

1920a	*Hypothyris cuboides* (Sowerby). Williams, p. 26.
1920b	*Hypothyris cuboides* (Sowerby). Williams, p. 8.
1924	*Hypothyris cuboides* Kindle, p. 35, 36.
1928	*Hypothyris cuboides* Dyer, p. 27.
1942	*Hypothyridina* Cooper et al., p. 1788.
1953	*Hypothyris cuboides* Martison, p. 44.
1975	*Hypothyridina* sp. Sanford and Norris, p. 76.

Material. One, poorly preserved, incomplete specimen.

Dimensions (mm) and other parameters.

Specimen	H569-1
Type No.	Hypotype GSC 94273
GSC Loc. No.	6570
Length of pv (Lpv)	21.4
Length of bv (Lbv)	18.4
Width (W)	23.0
Depth (D)	15.0
Ratio: W/Lpv	1.07
Ratio: D/Lpv	0.70

Description. Adult shell size about average for the genus; subpentagonal in outline with slightly rounded, fairly wide, front margin; unequally bioconvex; subcuboidal in shape; thickness seven tenths of length of shell; wider than long with greatest width about midlength; anterior commissure strongly uniplicate.

Pedicle valve strongly convex in lateral view and gently and broadly concave in anterior view, the median part flattened but the flanks weakly deflected in ventral direction. Umbonal region swollen; sulcus wide, very shallow, and defined anteriorly by weakly deflected anterolateral extremities; tongue long, moderately geniculate, and nearly straight anteriorly. Umbo narrowly convex; beak area damaged.

Dorsal valve very deep; gently convex in lateral profile, the surface sloping as the valve thickens anteriorly; anterior profile high, rounded dome with nearly flat sides; flanks gently convex and very slightly folded medianly at the anterolateral extremities. Umbo triangular, beak small, incurved, and hidden by opposite beak.

The exterior ornament has been preserved only on small areas of both valves. Where preserved, the exterior of both valves is marked by numerous, low, narrow plications that are separated by much narrower, angular furrows. Approximately 12 plications occur in the sulcus of the pedicle valve. Concentric growth lines are numerous, fine, and closely spaced. Shell substance is fibrous.

On the posterior lateral margin of the interior of the pedicle valve, closely spaced indentations and ridges, which probably served as a hinge mechanism in the articulation of the valves, can be seen. Similar markings can be seen on a specimen of *Hypothyridina emmonsi* (Hall and Whitfield) illustrated by Stainbrook (1948, Pl. 2, fig. 3) from the Independence Shale of Iowa.

There is a suggestion of a short median septum, as seen through the translucent shell of the brachial valve in the umbonal region.

Remarks. The informally designated *Hypothyridina*? sp. A from the Williams Island area bears the closest resemblance to young, thin variants of *Hypothyridina emmonsi rotunda* as illustrated by Cooper and Dutro (1982, p. 72, 73, Pl. 15, figs. 47–51) from the upper part of the Sly Gap Formation of New Mexico. *Hypothyridina*? sp. A differs from the New Mexico form by its more inflated and rounded pedicle umbo, and greater width to length ratio.

Hypothyridina? sp. A is distinguished from *Hypothyridina emmonsi* (Hall and Whitfield) from the Sly Gap Formation of New Mexico (Stainbrook, 1948, p. 773, Pl. 2, figs. 1–4, 11), from the Independence Shale of Iowa (Strainbrook, 1945, p. 42, Pl. 4, figs. 10–14), and from 600 ft. (182.9 m) above the base of the Mount Hawk Formation, Winnifred Pass, Alberta Rock Mountains (McLaren and Norris, *in* McLaren et al., 1962, p. 30, Pl. 14, figs. 10–12) by its thinner lateral profile, its lower and less geniculate pedicle tongue, and less conspicuous fold on the brachial valve.

Occurrence. GSC locality 6570, Field No. XVII. A 2 ft. (0.61 m) thick bed of green limestone with shale partings and containing considerable pyrite, outcropping on the west bank of the Abitibi River opposite Williams Island; collected by M.Y. Williams, August 29, 1919. Associated with *Calvinaria* sp. A. Although Kindle (1924, p. 34, 35) considered the

Hypothyridina-bearing bed to mark the uppermost Williams Island Formation, the presence of the associated *Calvinaria* sp. A indicates that the bed in question is part of the Long Rapids Formation.

Figured specimen. Hypotype GSC 94273, an incomplete, mature specimen.

Ib. RHYNCHONELLID BRACHIOPODS — P. SARTENAER

Order RHYNCHONELLIDA Kuhn, 1949

Superfamily RHYNCHONELLACEA Gray, 1848

Family UNCERTAIN (?aff. PUGNACIDAE)

Genus *Ladogioides* McLaren, 1961, p. 4

Type species. *Ladogioides pax* McLaren, 1961; OD.

Ladogioides pusilla Sartenaer n. sp.

Plate 3, figures 1-18; Figure 10A, B

1985 *Ladogioides pax* Telford, p. 14.

1986 *Ladogioides pax* McLaren. Norris, p. 36.

1989 *Ladogioides pax* Telford, p. 130.

Etymology. Latin, *pusillus, a, um*, dwarf. The name alludes to the small size of the species.

Diagnosis. *Ladogioides* of very small size at maturity, with a fold that is clearly separated from lateral slopes of shell, and generally with relatively few costae.

Material. Represented by 24 specimens, all but two of which (those illustrated), have been deformed by crushing.

Dimensions (mm) and other parameters.

Specimen	H577-1	H577-2	H577-3*
Type No.	Paratype ROM 47285	Holotype ROM 47286	Paratype ROM 47287
Locality No.	Ab-"11"	Ab-"11"	Ab-"11"
Length of pv (Lpv)	11.9	11.6	—
Length of bv (Lbv)	10.3	10.4	—
Width (W)	14.0	12.4	—
Depth (D)	8.5	8.1	—
Hinge line length (Lhl)	11.2	7.9	—
Hinge angle (in degrees)	113	116	—
Ratio: W/Lpv	1.18	1.07	—
Ratio: D/Lpv	0.71	0.70	—
Ratio: Lhl/W	0.80	0.64	—

*Specimen serially sectioned.

Description. Shell generally small (two illustrated specimens are of medium size), uniplicate, and very inequivalved. Most specimens subcircular in outline in ventral and dorsal views; outline of other specimens varies from somewhat transversely subelliptical (generally) to longitudinally subelliptical (rarely). Cardinal line slightly undulated. Commissures sharp and clearly indented by the costae. The change from lateral to frontal commissures is gradual, and thus not clearly marked.

Pedicle valve shallow and has a prominent umbonal region and slightly convex flanks. Sulcus originates at a distance from the beak; its relatively wide (two thirds to three quarters of the width of the shell at the junction of the frontal and lateral commissures), usually moderately deep, and rarely may be very deep. The bottom of the sulcus is flat. Trapezoidal tongue prominent, has sharp borders, and is usually moderately high, but exceptionally may be very high; upper part generally tends to become vertical, and is rarely recurved posteriorly. Top of tongue usually flat, but sometimes slightly convex. Top of the tongue almost always corresponds to top of shell. Prominent beak erect, resorbed at apex by circular foramen. Interarea long, high, and clearly delimited from flanks of valve by prominent beak ridges.

Profile of brachial valve in median longitudinal section resembles quarter of an ellipse. Flanks slope steeply from a noninflated umbonal region, and become flat or concave near the posterolateral commissures. Fold originates at a considerable distance from beak; it is usually moderately high, and rarely very high.

Costae simple, clearly marked, wide, angular with rounded tops, and generally low to moderately high, but occasionally may be high; confined to anterior half, sometimes to anterior third of shell; lateral costae sometimes reduced to mere indentations of commissure.

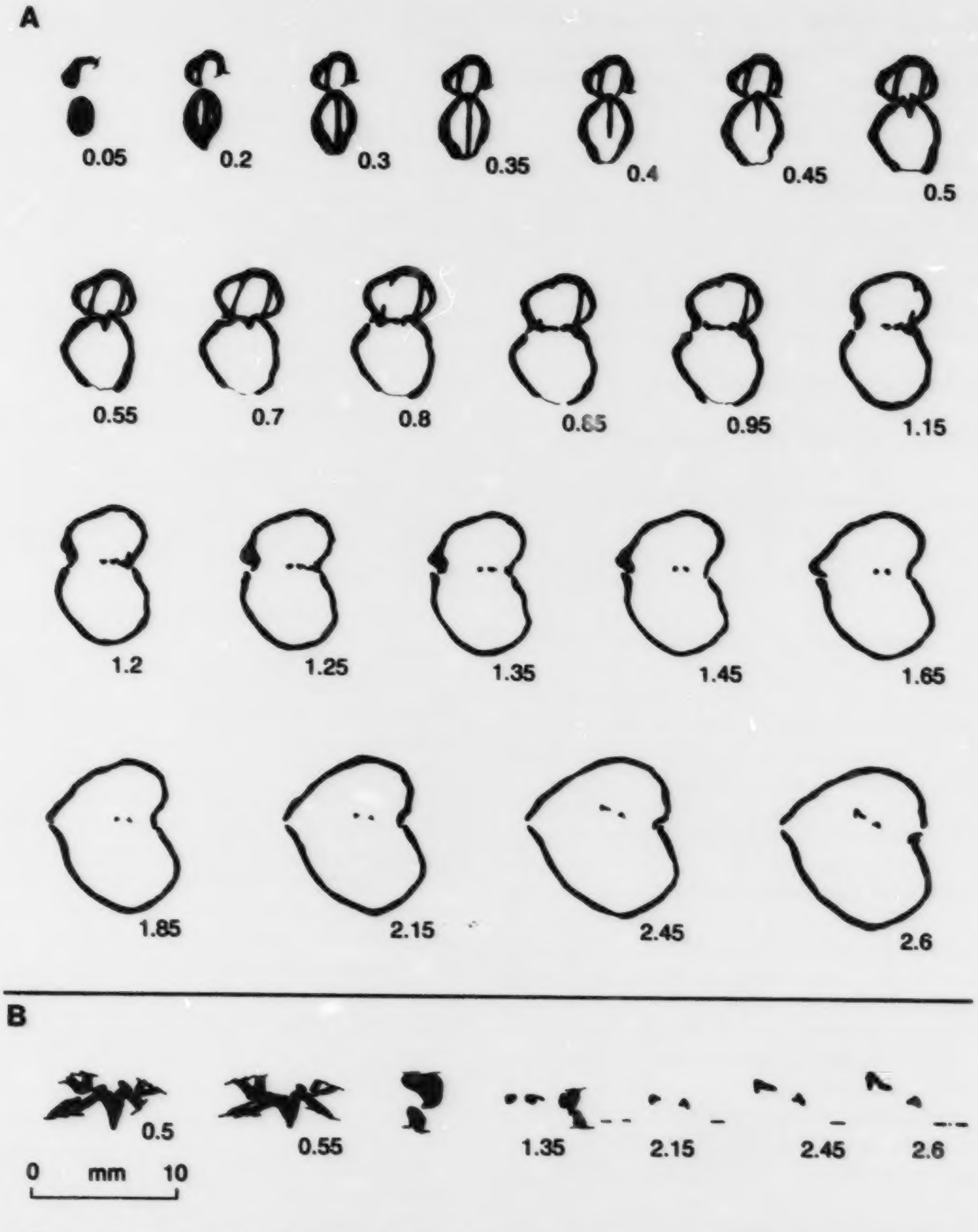

A
0.05
0.2
0.3
0.35
0.4
0.45
0.5
0.55
0.7
0.8
0.85
0.95
1.15
1.2
1.25
1.35
1.45
1.65
1.85
2.15
2.45
2.6
B
0.5
0.55
1.35
2.15
2.45
2.6
0 mm 10

Figure 10. *A. Camera lucida drawings of serial transverse sections of* ***Ladogioides pusilla*** *Sartenaer n. sp. Distances are in millimetres forward of the crest of the pedicle umbo. Measurements of this crushed specimen have not been taken. Paratype ROM 47287. Locality Ab-"11". B. Six transverse serial sections of the same specimen in A (magnification x2) showing various stages of development of the cardinalia and crura.*

Costae are few. Median costae: 2/1 (4 specimens); 3/2 (6 specimens); 4/3 (1 specimen). Lateral costae: 0 (3 specimens); 1/2 (1 specimen); 2/3 (5 specimens); 3/4 (1 specimen); 4/5 (1 specimen). There are no parietal costae.

Closely spaced, flattened costellae are a major external character of the genus *Ladogioides* McLaren, 1961. Remnants of similar costellae are faintly preserved in specimen H577-1.

Width of shell is largest dimension, but length only slightly less. Greatest width at about 60 per cent of the length of the shell anterior of the ventral umbo. Greatest thickness at or near anterior part of shell. Apical angle varies from 108 to 118 degrees.

Internal characters are typical for genus: dental plates, umbonal cavities, U-shaped delthyrial cavity, almost flat, divided hinge plates, narrow and deep septalium, slender and impersistent septum, low inner socket ridges, and crura that are dorsally grooved and become trough-shaped and slightly recurved anteriorly.

Discussion. Most of the characters of *Ladogioides pusilla* Sartenaer n. sp. and *L. pax* McLaren, 1961 are similar. *Ladogioides pusilla* n. sp. is differentiated by its considerably smaller size, by a fold that is more clearly separated from the lateral slopes of the shell, and by the fact that most specimens generally have fewer costae, although some have the same number of costae as commonly found on *L. pax*. Moreover, *L. pusilla* n. sp. never has a rounded to ogival anterior margin or a high acuminate form, and thus never reaches the thickness that is measured in some specimens of *L. pax*.

Occurrence. Locality Ab-"11" (=GSC loc. C-136485); green "clay-shale" bed, 1.3 m thick, uppermost Williams Island Formation; east bank of Abitibi River, immediately south of Williams Island.

Figured specimens. Holotype ROM 47286, a mature, relatively narrow, adult individual with costal formula of 2/1; 0; 3/4. Paratype ROM 47285, a mature, relatively wide, adult individual with costal formula of 3/2; 0; 4/5.

Family CAMAROTOECHIIDAE Schuchert and Le Vene, 1929

Subfamily LEIORHYNCHINAE Stainbrook, 1945

Genus *Calvinaria* Stainbrook

Type species. *Rhynchonella ambigua* Calvin, 1878, p. 729; OD.

Calvinaria sp. cf. *C. ambigua* (Calvin, S., 1878)

Plate 3, figures 19–28

1985 *Calvinaria* cf. *variabilis athabascensis*. Telford, p. 14.

1986 cf. *Calvinaria variabilis athabascensis* (Kindle). Norris, p. 37.

1989 *Calvinaria* cf. *variabilis athbascensis* Telford, p. 130.

Material, locality, and possible synonymy. Three specimens were collected by P.G. Telford in 1984 from a limestone bed, 0.3 m thick, 8.9 m above a goniatite bed and 16 m above the base of the Long Rapids Formation, on the east bank of the Abitibi River, immediately south of Williams Island (locality Ab-12; =GSC loc. C-136493). Only two specimens are briefly described here, because the third specimen is badly crushed. The specimens probably correspond to the species identified as *Leiorhynchus* sp. aff. *L. mesacostalis* by Savage and Van Tuyl (1919, p. 373), and mentioned again later by Dyer (1928, p. 28), Martison (1953, p. 44), Fritz et al. (1957, p. 25), and Sanford and Norris (1975, Pt. 1, p. 68).

Dimensions (mm) and other parameters.

Specimen	H580-1	H580-2
Type No.	Hypotype ROM 47288	Hypotype ROM 47289
Locality No.	Ab-12	Ab-12
Length of pv (Lpv)	25.2	25.1
Length of bv (Lbv)	24.1	24.0
Width (W)	34.5	33.4
Depth (D)	15.8	17.9
Hinge line length (Lhl)	22.0	17.8
Hinge angle (in degrees)	156	153
Depth of sulcus at anterior margin	13.9	17.7
Ratio: W/Lpv	1.37	1.33
Ratio: D/Lpv	0.45	0.71
Ratio: Lhl/W	0.64	0.53

Description. Shell medium to large; uniplicate and inequivalved. Outline of shell transversely subelliptical in ventral and dorsal views. Cardinal line is undulate. Commissures sharp and clearly indented by costae. Posterolateral margins concave near commissure.

Ventral flanks moderately convex. Sulcus moderately deep, well marked, starting at some distance from beak, clearly separated from flanks. Width of sulcus at junction of frontal and lateral commissures is 56 per cent of width of shell in one specimen, and 60 per cent in the other. Tongue moderately high, trapezoidal, has sharp borders, stands out clearly, and tends to become tangential to a vertical plane in its upper part. Beak suberect to erect and almost in contact with dorsal umbonal region. Interarea short and low, and has blunt borders.

Dorsal umbonal region almost tangential to a vertical plane in one specimen, extending beyond ventral umbonal region in the other. Highest part of brachial valve about midlength, and from there to frontal commissure is of even height in one specimen, and curves slightly toward commissure in the other. Fold is moderately high, well marked, and originates at some distance from beak.

Costae obtuse, angular with rounded tops, wide, and moderately high. Median costae (4/3) originate almost with sulcus and fold. Lateral costae (4/5) present in one specimen, but not evident in the other.

Maximum width of shell approximately at midlength, and notably greater than length. Apical angles: 153 and 156 degrees.

Transverse serial sections were not made because of limited material.

Discussion. The two specimens from Williams Island area cannot be differentiated from *Calvinaria ambigua* by external features, although they do not attain the large size common in adult specimens of that species. *Calvinaria ambigua* was collected originally from the "Independence Shale" in a quarry near Independence in northeastern Iowa. The *Ancyrognathus triangularis*, Lower and Upper *gigas* conodont zones occur in the Independence Shale, according to Müller and Müller (1957, p. 1073, 1074, 1077-1079), and Klapper and Furnish (1963, p. 402, 408). The two specimens from the Williams Island area are also closely similar to two specimens from the High Point Sandstone at High Point near Naples in southwestern New York, which were described by Stainbrook (1942, p. 883, 885, Pl. 2, figs. 14, 15, 20) as *Pugnoides ambigua* (Calvin). The High Point fauna, which is considered by Stainbrook (1942) as "closely related to that of the Independence shale of Iowa", has never been duplicated.

Figured specimens. Hypotype ROM 47288, a mature, relatively thin and wide, adult individual, with costal formula of 4/3; 0; 0. Hypotype ROM 47289, a relatively thick, adult individual, with costal formula of 4/3; 0; 4/5.

The following description is by A.W. Norris, with contributions by P. Sartenaer.

Calvinariid sp.

Plate 10, figures 7-14

Material. One nearly complete specimen; a fragmentary pedicle valve partly embedded in matrix, and a fragmentary brachial valve partly embedded in matrix.

Dimensions (mm) and other parameters.

Specimen	H580a-1	H580a-2 (pv)	H580a-3 (bv)
Type No.	Hypotype ROM 47290	Hypotype ROM 47291	Hypotype ROM 47292
GSC Loc. No.	100799 (= Ab-6)	100799 (= Ab-6)	100799 (= Ab-6)
Length of pv (Lpv)	19.9	17.2 (est.)	—
Length of bv (Lbv)	18.5	—	19.6
Width (W)	21.6	22.3 (est.)	—
Depth (D)	11.4	—	—
Hinge angle (in degrees)	138	128 (est.)	—
Depth of sulcus at anterior margin	5.4	—	—
Ratio: W/Lpv	1.09	1.30	—
Ratio: D/Lpv	0.57	—	—

Description. Shell small, moderately biconvex in lateral profile, transversely subpentagonal in outline; slightly wider than long with greatest width near midlength; hinge angle varies from 128 to 138 degrees for two specimens; front margin rounded, moderately extended; lateral margins curved vertrally toward front; anterior commissure slightly extended, broadly rounded, and uniplicate.

Pedicle valve moderately convex about same depth as brachial valve, with maximum depth at about midlength; smoothly curved longitudinally from beak to anterior commissure and more weakly curved transversely. Flanks flatten toward posterolateral margins. Sulcus starts at about midlength, gradually deepening anteriorly, and extending into a broad, flattened tongue. Beak small, strongly incurved, and inconspicuous. Interareas are narrow and bounded by weak beak ridges. Foramen is small and inconspicuous. Deltidial plates not seen.

Brachial valve is moderately convex with maximum depth about one third of length from umbo. Fold originates about midlength and widens very gradually anteriorly. Flanks flat laterally, gently convex posterolaterally, and gently concave anterolaterally. Beak incurved and covered by opposite valve.

Ornament conspicuous only on anterior half of shell; umbones are smooth. Fold marked by three low, broadly rounded costae. Lateral costae form edges of fold, and are about three times as wide as the median costa. Two faint costae occur in sulcus of pedicle valve. Flanks smooth. Faint, concentric, closely spaced growth lines on protected parts of shell.

Median septum seen through the shell, extending from apex of umbo to near midlength of interior of brachial valve.

Discussion. The Long Rapids form bears a close resemblance to *Calvinaria albertensis albertensis* (Warren) as described and illustrated by McLaren (1962, p. 26, Pl. 1, figs. 1-11, Textfig. 6B, C) from the Mount Hawk Formation of the Alberta Rocky Mountains and equivalent beds of the Northwest Territories. *Calvinaria a. albertensis*, although extremely variable in form, is consistently recognizable, according to McLaren (1962, p. 25). The Long Rapids form differs from the more typical *C. a. albertensis* by having three, low, rounded costae on the fold rather than two, and two costae in the sulcus rather than one; and by a lower uniplicate anterior commissure.

In size and shape this form also resembles *Calvinaria bransoni* Stainbrook (1948, p. 774, 775, Pl. 2, figs. 12-16) from the Sly Gap Foramtion of New Mexico. The Long Rapids form is distinguished by its more transverse outline, less inflated lateral profile, less pronounced, lower, and more rounded costae on the fold, and the absence of well developed costae on the front margins of the flanks.

Occurrence. GSC locality 100799 (=locality Ab-6), Long Rapids Formation, 8.2 m above the base of the section, east bank of Abitibi River, immediately south of Williams Island. Associated with numerous species of *Manticoceras* sp. cf. *M. sinuosum* (Hall).

Figured specimen. Hypotype ROM 47290, an almost complete, mature specimen.

The following description is by A.W. Norris, with contributions by P. Sartenaer.

Calvinaria sp. A

Plate 10, figure 15

1920a *Leiorhynchus*(?) sp. Williams, p. 26.

1920b *Leiorhynchus*(?) sp. Williams, p. 8.

1975 *Leiorhynchus*(?) sp. A. Sanford and Norris, p. 76.

Material. One incomplete pedicle valve.

Dimensions (mm) and other parameters.

Specimen	H580b-1
Type No.	Hypotype GSC 94274
GSC Loc. No.	6570
Length of pv (Lpv)	23.8
Width (W)	31.2
Depth of sulcus at anterior margin	10.1
Ratio: W/Lpv	1.31

Description. Pedicle valve from mature, adult individual, about average size for genus; outline transversely subpentagonal, considerably wider than long; greatest width about midlength; front margin truncated; broadly uniplicate.

Pedicle valve moderately convex, highest about midlength; middle of anterior half of valve occupied by a broad sinus, which widens and deepens anteriorly. Sides of sinus marked by strong, subangular costae tilted laterally; costae decrease in height and strength posteriorly and converge over the umbo; strong, subangular fold in middle of sinus; fold decreases in strength, becomes rounded posteriorly, merges with pedicle umbo; two angular costae occur on each side of sinus along anterior margins of the flanks, and of these the inner costae are considerably larger and more conspicuous. Umbo swollen, tapering to a rounded V-shape toward apex; beak inturned and not seen.

Posterolateral and umbonal regions smooth. Shell material thin and translucent. Fine, closely spaced, concentric growth lines evident on depressed, protected parts of shell.

Remarks. Limited material precludes a detailed comparison with other forms. The closest comparison of the specimen at hand is with the holotype of *Calvinaria ambigua* (Calvin) from the Indepenedence Shale of Iowa, described and illustrated by Stainbrook (1945, p. 44, Pl. 4, figs. 3, 4). The most conspicuous features that the Independence Shale and Williams Island forms have in common are comparable size, transverse elliptical outline, and the single median costa in the sulcus of the pedicle valve. However, the Williams Island form is distinct in having two, rather than three or more, costae on the flanks of the pedicle valve.

Occurrence. GSC locality 6570 (Field No. XVII). A 2 ft. (0.61 m) thick bed of green limestone with shale partings and considerable pyrite; outcropping on the west bank of the Abitibi River, opposite Williams Island; collected by M.Y. Williams, August 29, 1919; associated with *Hypothyridina*? sp. A.

Figured specimen. Hypotype GSC 94274; an incomplete pedicle valve of an adult individual.

Genus *Leiorhynchus* Hall, 1860b, p. 75

Type species. *Orthis quadracostata* Vanuxem, 1842, p. 168; SD Oehlert, 1887, p. 1308. [=*Liorhynchus* Oehlert, 1887 (obj.) (*non* Rudolphi, 1801); *Nudirostra* Cooper and Muir-Wood, 1951 (obj.)].

Leiorhynchus quadracostatus alces

Sartenaer n. subsp.

Plate 3, figures 29-33; Plate 4, figures 1-36; Figure 11

1919 *Leiorhynchus* near *globuliformis* Savage and Van Tuyl, p. 373.

1928 *Leiorhynchus* cf. *quadricostata* Dyer, p. 27.

1928 *Leiorhynchus* near *globuliformis* Savage and Van Tuyl *in* Dyer, p. 28.

1928 *Leiorhynchus* cf. *quadricostalis* Dyer, p. 28.

1953 *Leiorhynchus* near *globuliformis* Savage and Van Tuyl *in* Martison, p. 44.

1953 *Leiorhynchus* cf. *quadricostalis* Dyer *in* Martison, p. 44.

1957 *Leiorhynchus quadricostatus* Dyer *in* Fritz et al., p. 25.

1957 *Leiorhynchus* sp. (aff. *globuliformis*) Savage and Van Tuyl *in* Fritz et al., p. 25.

1975 *Leiorhynchus* near *globuliformis* Savage and Van Tuyl *in* Sanford and Norris, Pt. 1, p. 68.

1975 a species closely similar to, but distinct from *Leiorhynchus* (e.p.) *quadracostatus* (Vanuxem). Sartenaer in Sanford and Norris, Pt. 1, p. 68, 70, 85.

1975 "*Leiorhynchus* cf. *quadricostata*" Dyer *in* Sanford and Norris, Pt. 1, p. 68.

1985 *Leiorhynhus* sp. cf. *L. quadricostatus* (Vanuxem). Norris *in* McGregor et al., p. 168.

1985 *Leiorhynchus* cf. *quadracostatum* Telford, p. 14.

1986 cf. *Leiorhynchus quadracostatus* (Vanuxem). Norris, p. 36.

1989 *Leiorhychus* cf. *quadracostatum* Telford, p. 130.

Etymology. Latin, *alces*, moose. The name alludes to the geographic source area of the subspecies in the Moose River Basin, northern Ontario. (*Alces* is used as a noun standing in apposition.)

Diagnosis. *Leiorhynchus quadracostatus* of small to medium size at maturity, with a relatively high number of median costae, a low number or complete absence of lateral costae, and commonly with a slight, anterior depression on the fold.

Material. 26 specimens from locality Ab-"11" (=GSC loc. C-136485), of which all but two specimens are small, very thin, crushed, or otherwise deformed. Forty specimens are from locality JM-1 and almost all of these are larger and more inflated than the specimens from locality Ab-"11".

Dimensions. (see also Dimensions table on p. 47)

Although length and width of shells have closely similar values, width generally slightly exceeds length. Maximum width of shells between 46 to 61 per cent of shell length anterior of ventral umbo.

Brachial valve, with very rare exceptions, much thicker than pedicle valve. Highest part of pedicle valve located between 22 and 43 per cent of shell length forward of ventral beak or between 22 and 39 per cent of unrolled length of valve.

Apical angle varies from 108 to 131 degrees, but most values are between 115 and 123 degrees.

Dimensions (mm) and other parameters.

Specimen	A	B	C	D	E	F	G*	L	H*	I*	J+	K
Type No.	Paratype ROM 47293	Paratype ROM 47294	Paratype ROM 47295	Paratype ROM 47296	Paratype ROM 47297	Paratype ROM 47298	Paratype ROM 47299	Holotype ROM 47300	Paratype ROM 47301	Paratype ROM 47302	Paratype ROM 47303	Paratype ROM 47304
Locality No.	Ab-"11"	JM-1	JM-1	JM-1	JM-1	JM-1	JM-1	JM-1	JM-1	JM-1	JM-1	Ab-"11"
Length of pv (Lpv)	15.5	20.3	17.9	17.7	16.0	16.7	17.3	17.1	17.1	17.5	17.7	11.2
Width (W)	18.7	20.2	17.6	20.5	17.8	16.2	18.5	19.9	20.3	17.2	18.2	13.0
Length of pv (unrolled)	24.0	30.2	24.5	24.5	23.5	24.5	24.0	26.5	24.0	23.5	—	13.3
Depth of shell (Ds)	12.6	16.2	15.1	14.2	14.5	14.6	13.5	15.7	13.7	13.1	14.2	5.5
Depth of pv (Dpv)	6.0	4.7	6.5	5.4	5.2	4.7	5.0	5.4	5.8	3.5	—	2.1
Depth of bv (Dbv)	6.6	11.5	8.6	8.8	9.3	9.9	8.5	10.3	7.9	9.6	—	2.0
Ratio: Lpv/W	0.83	1	1.02	0.86	0.9	1.03	0.94	0.86	0.84	1.02	0.97	0.86
Ratio: Ds/W	0.67	0.8	0.86	0.69	0.81	0.9	0.73	0.79	0.67	0.76	0.78	0.42
Ratio: Ds/Lpv	0.81	0.8	0.84	0.80	0.91	0.87	0.78	0.92	0.8	0.75	0.80	0.49
Apical angle (in degrees)	113	115	117	123	115	109	121	121	131	116	—	117

*Specimens not illustrated. +Specimen serially sectioned.

Description. Shell small to medium, uniplicate, globular, and very inequivalved. Outline of shell in ventral view highly variable, as follows: subcircular with sometimes a subpentagonal aspect (40 per cent), transversely subelliptical (35 per cent), or longitudinally subelliptical (25 per cent). Outline of the shell, in frontal view, is helmet-like in upper part (brachial valve) and a flattened half-ellipse in lower part (pedicle valve). This outline changes near commissure, where pedicle valve becomes flat or concave. Cardinal line undulated. Commissures sharp. Both anterior and lateral commissures slightly undulated by costae, when lateral costae are present. Both valves inflated as seen in lateral profile resulting in high lateral commissures. Highest part of shell never coincides with highest part of tongue. Cardinal margins concave near commissure.

Outline of pedicle valve a flattened to elliptical arch in longitudinal median section, varying from low to moderately high half-ellipse to half-egg shape in longitudinal lateral section; in transverse median section, an almost flattened half-ellipse, of which the sides are often flat or even concave near commissures. Umbonal region prominent; flanks slope somewhat steeply, but flatten toward and near commissures, where the flanks generally become concave. Sulcus starts clearly and with a noticeable width at a relatively great distance from the beak (42 to 69 per cent of shell length, or 34 to 62 per cent of unrolled length of valve). Sulcus reaches greater width (62 to 80 per cent of shell width) at junction of frontal and lateral commissures. Bottom of sulcus generally slightly convex, and sometimes flat. Although of low depth, the sulcus is clearly separated from the flanks. Trapezoidal tongue prominent, has sharp borders and variable height; upper part extended anteriorly. Top of tongue generally flat, sometimes slightly convex; affected by median depression commonly present on fold of opposite valve. Top of tongue corresponds to most anterior part of shell at front. Beak short, thick, wide, suberect to erect, resorbed by a small, circular foramen; beak comes close to dorsal umbonal region, sometimes in contact with it. There is no clearly delimited interarea. Tiny deltidial plates have been observed in transverse serial sections.

Contour of brachial valve, in median longitudinal section between umbo and top of valve, is one quarter of shell circumference. Top of valve reached between 43 and 60 per cent of shell length; from there valve slopes somewhat steeply toward front. Height of shell at front accounts for between two thirds and four fifths of total thickness of shell. Dorsal umbonal region smoothly rounded; beak strongly inturned and covered. Convex flanks slope steeply, become concave near anterolateral commissures. Fold slightly to moderately high, clearly separated from flanks, starting nearer beak than the sulcus does. Top of fold generally flat, sometimes slightly convex. In slightly more than half the specimens, the portion of the fold that is located between the bordering costae is slightly depressed anteriorly at between one third and two thirds of shell length.

Ornament. General costal formula is 4/3 to 6/5; 0; 0. This formula is a grouping of a least 75 per cent of the specimens in the categories median, parietal, and lateral costae, respectively.

The ratios of median costae in 25 mature and 34 juvenile specimens in which such observations could be made are distributed as follows:

	Adult		**Juvenile**	
Ratio	No. of Spec.	%	No. of Spec.	%
2/1	1	4	1	2.95
3/2	4	16	7	20.6
4/3	9	36	14	41.15
5/4	6	24	7	20.6
6/5	5	20	5	14.7

Median costae flattened, wide (1 to 2.5 mm at anterior margin), obtuse with rounded tops, or rounded; usually originating posterior to beginning of sulcus and fold, and sometimes near beak; costae regular when not affected by divisions. One specimen out of eight shows a division in anterior third of shell; two divided costae were observed in one specimen, three in another. Unusually, costae in the sulcus have been obliterated by abrasion.

There are no parietal costae.

Lateral costae usually absent, but have been counted on eight specimens as follows: 1/2 (2 specimens); 2/3 (3 specimens); 3/4 (1 specimen); 5/6 (1 specimen); and 7/8 (1 specimen). In first six specimens, costae restricted to extreme anterior margin of flanks, producing slight undulations in commissure; in remaining two specimens costae start from umbonal region and do not affect commissures.

Internal characters. Internal characters of this subspecies are those typical of the genus *Leiorhynchus*, and include: short and stout dental plates, well developed umbonal cavities, small robust teeth, stout and long septum thickened and lens-like posteriorly, crural trough, divided hinge plate, slender crura with characteristic shape, and spindle-shaped dorsal muscle scars.

Discussion. When I visited the Department of Geology, University of Illinois, in Urbana, on 19 October 1967, I examined about 56 specimens of the species referred to as *Leiorhynchus* near *globuliformis* by Savage and Van Tuyl (1919), including 2 specimens numbered 1088, 6 specimens numbered 1099, 8 specimens numbered 1110, and about 40 specimens without a number. It would have been helpful to incorporate the study of this material in the present paper, but unfortunately the material could not be located again. However, it is clear that the form examined in 1967 is the same as the one contained in the new collections by J. Monteith in 1952 and by P.G. Telford in 1984.

Leiorhynchus quadracostatus alces n. subsp. resembles in most characteristics *L. quadracostatus* (Vanuxem, 1842), the type species of the genus *Leiorhynchus* Hall, 1860b, from southwestern New York and of latest Givetian age, but is easily distinguished by its ornament and other characters as follows: the general costal formula is different, showing a tendency toward a higher number of median costae and a lower number or absence of lateral costae; the number of median costae is more variable; median costae originate anterior to the beak, and, although they sometimes start at a short distance from the beak, they never start at the beak; lateral costae are less often present and are mostly restricted to the anterior margin of the flanks. Also, *L. quadracostatus alces* n. subsp. is always small to medium sized and, in more than half the specimens, shows a slight anterior depression on the fold. Additional minor differences include a somewhat higher fold and a somewhat deeper sulcus in *L. quadracostatus alces* n. subsp.

The closest form to *L. quadracostatus alces* n. subsp. is an undescribed species of the same size from the Craghead Shale (=Snyder Creek Shale) of central Missouri, named *L.* sp. nov. by Gregor (1909, p. 376; 1936, p. 51).

The globular aspect of *L. quadracostatus alces* n. subsp., as well as the inadequate figure of the primary type (cast of a brachial valve) and the poor state of preservation of subsequent hypotypes and collections of *L. globuliformis* (Vanuxem, 1842), make it

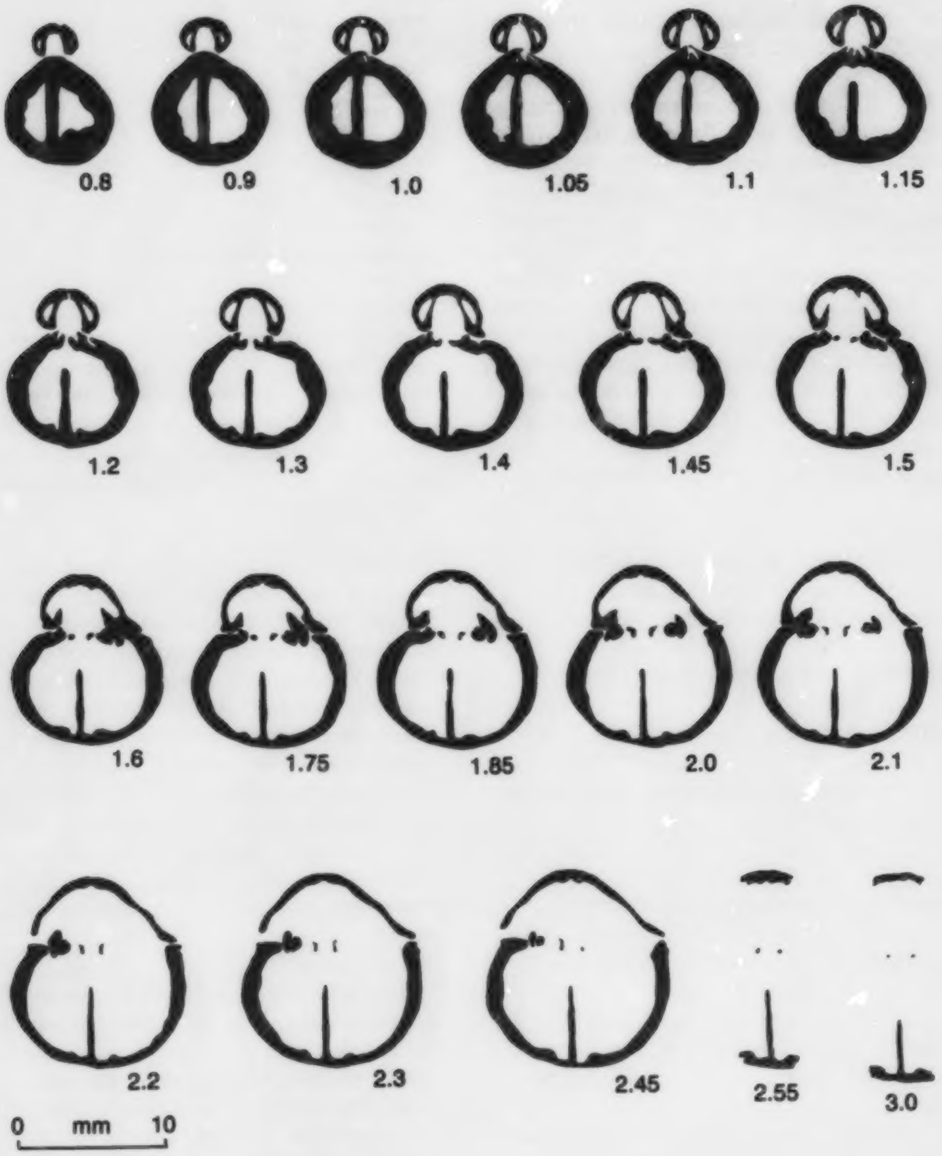


Figure 11. Camera lucida drawings of serial transverse sections of a specimen of Leiorhynchus quadracostatus alces Sartenaer n. subsp. Distances are in millimetres forward of the crest of the dorsal umbo. Paratype ROM 47303. Locality JM-1.

conceivable that Savage and Van Tuyl (1919) considered the Ontario species to be close to it. *Leiorhynchus globuliformis* from the "Chemung" of southwestern New York is different, although still insufficiently known. Harrington (1972, p. 278, Fig. 1, p. 279, Pl. 1, figs. 6–10, p. 280, 281) assigned it to the genus *Caryorhynchus* Crickmay, 1952, but Sartenaer (1974, p. 5) was uncertain about its position because of the lack of well preserved specimens of this species.

Occurrence. Locality JM-1; upper argillaceous limestone beds of the Williams Island Formation, west bank of Abitibi River, 0.25 mi. (0.4 km) downstream from the north end of Williams Island; specimens collected by J. Monteith, 1952.

Locality Ab-"11" (=GSC loc. C-136485); green, "clay-shale" bed, 1.3 m thick, uppermost Williams Island Formation, east bank of Abitibi River, immediately south of Williams Island; specimens collected by P.G. Telford, 1984.

Material. The following specimens are illustrated herein, except where indicated. Paratype ROM 47304, a young, thin shell; paratype ROM 47293, a relatively smooth, young adult shell; paratype ROM 47294, an elongate, adult shell; paratype ROM 47295, a relatively small, elongate, adult shell; paratype ROM 47296, a circular, adult shell; paratype ROM 47297, a small, rotund, adult shell; paratype ROM 47298, a small, elongate, adult shell; paratype ROM 47299, a relatively thin, adult shell (not photographed); holotype ROM 47300, a circular, thick, adult shell; paratype ROM 47301, a relatively large, thin, adult shell (not photographed); and paratype ROM 47302, a relatively thick, elongate, adult shell (not photographed).

Order ATRYPIDA Rzhonsnitskaya, 1960

Family ATRYPIDAE Gill, 1871

Subfamily ATRYPINAE Gill, 1871

Genus *Atryparia* Copper, 1966

Type species. *Atryparia instita* Copper, 1966, p. 983, 984, Fig. 2, 1–4.

Atryparia rubra Cooper and Dutro

Plate 4, figures 37–43, Plate 5, figures 1–13
Figure 12

1982 *Atryparia rubra* Cooper and Dutro, p. 86, Pl. 21, figs. 38–53.

Material. 20 complete and 8 incomplete specimens.

Dimensions (mm) and other parameters.

Specimen	H639-1	H639-2	H639-3	H639-4	H639-5*
Type No.	Hypotype ROM 47305	Hypotype ROM 47306	Hypotype ROM 47307	Hypotype ROM 47308	Hypotype ROM 47309
Locality No.	Ab-"11"	Ab-"11"	Ab-"11"	Ab-"11"	Ab-"11"
Length of pv (Lpv)	35.8	33.8	30.0	14.8	27.5
Length of bv (Lbv)	35.1	32.8	28.1	13.8	27.7
Width (W)	36.9	34.9	30.1	17.8	30.9
Depth (D)	20.5	20.0	17.1	9.2	14.7
Depth of sulcus at anterior margin	18.9	12.9	10.2	3.8	6.2
Ratio: W/Lpv	1.03	1.03	1.00	1.20	1.12
Costae in 5 mm, 10 mm from beak	pv 7 bv 7	pv 7 bv 6	pv 7 bv 6	pv 5 bv 5	pv 5 bv 5
Costae in 5 mm, 20 mm from beak	pv 5 bv 5	pv 4 bv 4	pv 5 bv 7	pv — bv —	pv 5 bv 4

*Specimen serially sectioned.

Description. Shell large at maturity, subquadrate to suboval in outline, width slightly greater than length in adult stages, but rare young individuals in the population may be considerably wider than long; lateral margins variably rounded; anterior margin commonly slightly extended, infrequently slightly indented; anterior commissure strongly and commonly narrowly uniplicate.

Pedicle valve weakly to moderately convex, highest along midline between one quarter and one third of length from beak, lateral slopes flattened. Sulcus shallow and vaguely defined in young stages, becoming slightly deeper and moderately to strongly upturned near the anterior margin to form a tongue in opposite valve. Beak small, rounded, and short. Interarea in young stages low, narrow, round-edged laterally, and anacline; in adult stages it is closely appressed against the opposite valve and covered. Delthyrium with two wedge-shaped deltidial plates and a raised pedicle collar evident in young stages, covered in later stages. Foramen oval-shaped, relatively large, permesothyridid.

Brachial valve considerably more convex than opposite valve, in adult shells depth of valve is about three times greater than the opposite valve. Greatest height at about one third to one half of length from beak. Posterolateral slopes commonly slightly extended and concave. Lateral slopes steep and flattened. Anterior medial part of valve has an indistinct, rounded fold that widens anteriorly. Beak hidden by opposite valve.

Surface of both valves ornamented by medium to coarse, round-crested costae, which increase in number anteriorly mainly by bifurcation but also by implantation; costae separated by rounded troughs equal or slightly narrower in width. The increase in size of costae anteriorly is very gradual. Concentration of costae at 10 mm from the apex varies from 5 to 7 in 5 mm of arc; at 20 mm from the apex, the number varies from 4 to 7 in 5 mm of arc. Concentric growth lamellae are widely and irregularly spaced on posterior part of shell, more closely spaced and commonly

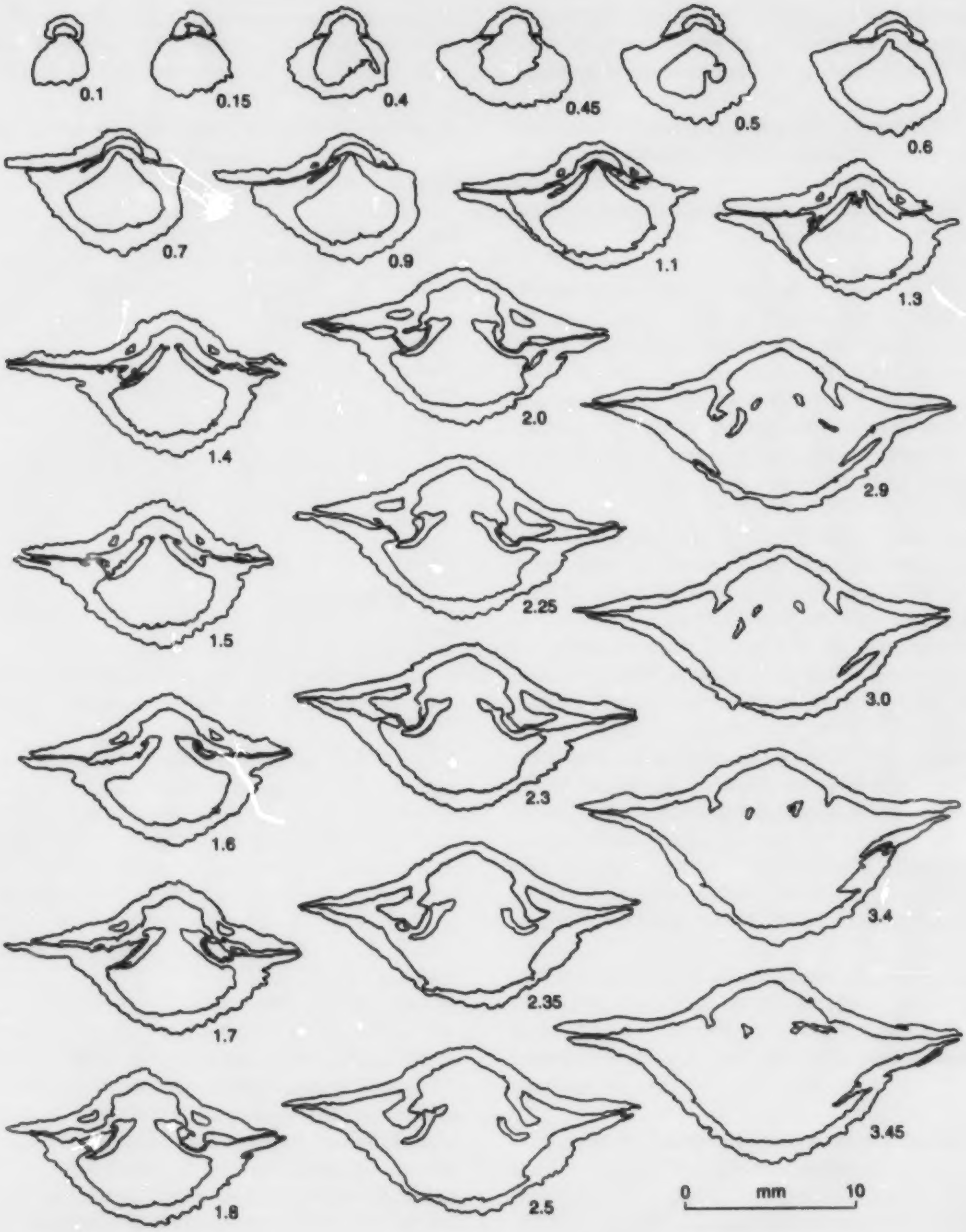


***Figure 12.** Transverse serial sections of a specimen of Atryparia rubra Cooper and Dutro. Distances are in millimetres forward of the crest of the pedicle umbo. Hypotype ROM 47309. Locality Ab-"11".*

crowded toward the anterolateral margins. Frills thin, recumbent, and fragile, but where preserved extend up to 8 mm beyond anterolateral margin. Microscopic, closely spaced, concentric growth lines evident on better preserved parts of shell.

Interior of pedicle valve has small lateral cavities that gradually enlarge anteriorly; teeth relatively stout, extending obliquely inward; teeth supported by relatively thick dental and dental buttress plates.

Interior of brachial valve has small, comb-like cardinal process; divided hinge plate relatively thin; teeth sockets denticulate apically; crural bases bulbous.

Discussion. Externally, there is a remarkable similarity between the form from the Williams Island Formation of northern Ontario and *Atryparia rubra* Cooper and Dutro (1982, p. 86, Pl. 21, figs. 38–53) from the Oñate Formation of New Mexico.

The type species of the genus, *Atryparia instita* Copper (1966, p. 983, 984, Fig. 2, 1–4), is from the upper layers of the Mullert Horizon, Ahbach Beds, upper Eifelian, Hillesheim Syncline, Eifel area of Western Germany. The form from northern Ontario is distinguished from the type species by its finer costae, more convex pedicle valve, more evenly convex pedicle umbo, and larger size at maturity.

Occurrence. Locality Ab-"11" (=GSC loc. C-136485); green "clay-shale" bed, 1.3 m thick, uppermost Williams Island Formation; east bank of Abitibi River, immediately south of Williams Island.

Figured specimens. Hypotype ROM 47305, a mature adult individual with some preserved alate laminae; hypotype ROM 47306, an elongate, adult shell; hypotype ROM 46707, a young adult shell; hypotype ROM 47308, a young, wide shell; hypotype ROM 47309, a wide, young, adult shell (serially sectioned, see Fig. 12).

Subfamily VARIATRYPINAE Copper, 1978

Genus *Desquamatia* Alekseeva, 1960; Biernat, 1964

Type species. Atrypa (*Desquamatia*) *khavae* Alekseeva, 1960.

Subgenus *Desquamatia* (*Independatrypa*) Copper, 1973

Type species. Atrypa independensis Webster, 1921, p. 15 (see Fenton and Fenton, 1935).

Desquamatia (*Independatrypa*) *exila*
Norris n. sp.

Plate 5, figures 14–39, Figure 13

Etymology. Latin, *exilis*, thin, slender, meager, weak; in allusion to common presence of thin forms.

Diagnosis. Desquamatia (*Independatrypa*) of small size at maturity, with a relatively thin lateral profile, an oval outline, and conspicuous growth lamellae.

Material. 14 complete, and one incomplete, specimens.

Dimensions (mm) and other parameters.

Specimen	H639a-1	H639a-2	H639a-3	H639a-4	H639a-5*	H639a-6*
Type No.	Paratype ROM 47310	Holotype ROM 47311	Paratype ROM 47312	Paratype ROM 47313	Paratype ROM 47314	Paratype ROM 47315
Locality No.	Ab-"11"	Ab-"11"	Ab-"11"	Ab-"11"	Ab-"11"	Ab-"11"
Length of pv (Lpv)	21.3	16.9	16.7	13.8	13.2	9.8
Length of bv (Lbv)	20.5	16.2	16.0	13.2	12.5	9.3
Width (W)	21.8	19.5	18.2	18.8	13.4	10.5
Depth (D)	7.5	6.9	8.8	6.4	5.4	4.1
Depth of sulcus at anterior margin	3.0	3.0	1.8	1.4	0	0.7
Hinge line length (Lhl)	16.6	13.0	12.2	8.0	9.1	—
Hinge angle (in degrees)	148	158	151	152	152	—
Ratio: W/Lpv	1.02	1.16	1.09	1.00	1.02	1.07
Ratio: D/Lpv	0.35	0.40	0.53	0.46	0.41	0.42
Ratio: Lhl/W	0.76	0.67	0.67	0.58	0.68	—
Costae in 5 mm, 10 mm from beak	pv 11 bv 10	pv 9 bv 9	pv 12 bv 12	pv 12 bv 11	pv 10 bv 11	pv 12 bv 11

*Specimens serially sectioned.

Description. Shell small, and relatively thin for subgenus, about equally biconvex in young stages, tending to highly unequal biconvexity in later stages, with brachial valve more highly inflated. Outline suboval in young stages to subsemicircular in adult stages. Generally slightly wider than long, with greatest width near midlength of shell. Posterolateral margins rounded; lateral margins broadly rounded and gently convex ventrally. Anterior commissure weakly to moderately uniplicate.

Pedicle valve gently arched along midline from beak to front; highest immediately anterior of umbo; gently arched transversely, flattened and recurved to become concave toward lateral and anterior margins. Sulcus absent in young stages, variably rounded, U- and V-shaped and upturned, or geniculate ventrally in some

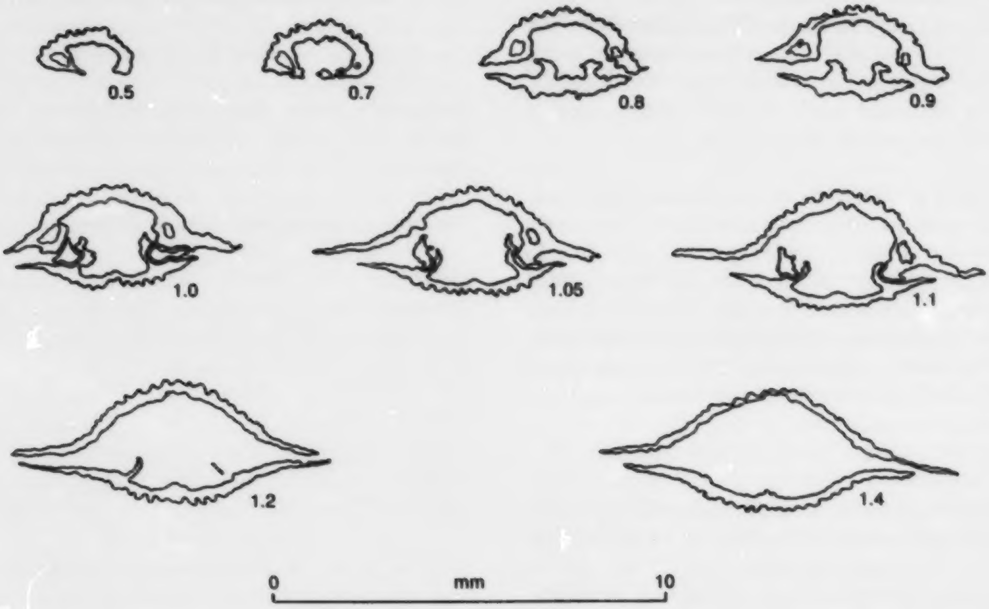


*Figure 13. Transverse serial sections of a specimen of **Desquamatia (Independatrypa) exila** Norris n. sp. Distances are in millimetres forward of the beak of the pedicle valve. Paratype ROM 47315. Locality Ab-"11".*

adult specimens. Beak small, pointed, very short, erect in young stages, moderately incurved in later stages. Interarea low, relatively narrow, round-edged laterally, apsacline in young stages, becoming anacline and covered by opposite valve in later stages. Delthyrium with two wedge-shaped deltidial plates, pierced apically by a submesothyridid to mesothyridid oval-shaped foramen having a slightly raised rim.

Brachial valve nearly equal in convexity to opposite valve in young stages, but becoming more inflated to account for about three quarters of the depth of shell in later stages. Moderately convex along midline from back to front, highest at about one third of length from beak; flanks slope steeply laterally and anterolaterally, recurved posterolaterally in all specimens, and also laterally and anteriorly in some specimens. Fold indistinct, evident at and near anterior margin in older shells. Beak small, strongly incurved, and hidden by opposite valve.

Surface of both valves ornamented by very fine, radiating, round-crested costae, which increase in number anteriorly mainly by bifurcation but also by implantation; costae separated by rounded troughs of generally less width. Costae increase in strength gradually anteriorly. Number of costae varies from 9 to 12 in 5 mm of arc, 10 mm from the beaks. Concentric growth lamellae are fairly regularly spaced about 4 mm apart over most of shell but become crowded and more irregularly spaced toward the lateral and anterior margins, where they are better preserved and longer. Microscopic, concentric, closely spaced growth lines are evident on better preserved parts of shell.

Interior of pedicle valve has relatively stout teeth extending obliquely inward, partly separated from inner shell wall by relatively large lateral cavities. Teeth supported by moderately thin dental and dental buttress plates.

Interior of brachial valve has dental sockets between inner shell wall and extensions of hinge plates. Crural lobes slender and curved laterally. A low, blunt, median ridge separates the muscle field, coinciding with a shallow mesial sinus on exterior of posterior part of brachial valve.

Comparison. On features such as relatively small size, fine costae, and development of growth lamellae, *Desquamatia* (*Independatrypa*) *exila* n. sp. is most closely comparable to *Atrypa independensis janesvillensis* Fenton and Fenton (1935, p. 379, Pl. 42, figs. 9–13) described from the lower Cedar Valley Limestone of Iowa, in beds referred to as the *independensis* Zone by Stainbrook (1938b, p. 231). *Desquamatia* (*I.*) *exila* n. sp. is distinguished from the Iowa species by its smaller size, relative thinness, more suboval and semicircular rather than subquadrate outline, less extended beak in adult stages, and a smaller width to pedicle length ratio.

Desquamatia (*I.*) *exila* n. sp. is distinguished from *D.* (*I.*) *independensis* (Webster) as described by Norris (*in* Norris and Uyeno, 1983, p. 24, 25, Pl. 5, figs. 14–23, Pl. 8, figs. 5, 6) from the Peace Point Member of the Waterways Formation, Gypsum Cliffs, Peace River, northeastern Alberta, by its smaller size at maturity, its more oval rather than subquadrate outline, thinner lateral profile, and smaller and less extended pedicle beak.

Desquamatia (*I.*) *exila* n. sp. is easily distinguished from *Atrypa independensis* Webster as described and illustrated by McCammon (1960, p. 53, 54, Pl. 9, figs. 1, 2, 4; not fig. 3) from the argillaceous limestone beds of the Point Wilkins Member of the Souris River Formation of Manitoba (see Norris et al., 1982), by its smaller size, thinner lateral profile, smaller and less extended pedicle break, and its more oval rather than subquadrate outline.

Desquamatia (*I.*) *exila* n. sp. is probably most closely similar to an unusually thin and circular form designated as a "discoid" *Atrypa* sp. and illustrated by Raasch (Maurin and Raasch, 1972, Pl. 12, figs. 1–7) from the middle part of their Assemblage 4 (sample 502) of the upper Flume Formation, Kakwa Lake, British Columbia. The minor differences that distinguish *D.* (*I.*) *exila* n. sp. from the Kakwa Lake form are a less circular outline, a slightly thicker lateral profile, generally a longer and straighter hinge line, and a slightly more extended pedicle beak.

Occurrence. Locality Ab-"11" (=GSC loc. C-136485); green, "clay-shale" bed, 1.3 m thick, uppermost Williams Island Formation; east bank of Abitibi River, immediately south of Williams Island.

Figured and/or measured specimens. Paratype ROM 47310, a mature, thin, adult shell; holotype ROM 47311, a young, broad, thin, adult shell; paratype ROM 47312, a young, relatively thick, elongate shell; paratype ROM 47313, a young, elongate shell; paratype ROM 47314, a thin, circular shell (serially sectioned); and paratype ROM 47315, a young, thin, circular shell (serially sectioned).

Desquamatia (*Independatrypa*) sp. A

Plate 6, figures 1–19

Material. Four complete and two incomplete specimens.

Dimensions (mm) and other parameters.

Specimen	H639b-1	H639-2	H639b-3
Type No.	Hypotype ROM 47316	Hypotype ROM 47317	Hypotype ROM 47318
Locality No.	Ab-"11"	Ab-"11"	Ab-"11"
Length of pv (Lpv)	14.0	12.8	12.9
Length of bv (Lbv)	12.8	12.5	12.0
Width (W)	15.4	13.0	13.0
Depth (D)	7.4	6.3	5.0
Hinge line length (Lhl)	9.4	8.8	8.7
Hinge angle (in degrees)	143	160	155
Depth of sulcus at anterior margin	1.2	1.4	1.0
Ratio: W/Lpv	1.10	1.08	1.01
Ratio: D/Lpv	0.53	0.49	0.39
Ratio: Lhl/W	0.61	0.68	0.67
Costae in 5 mm, 10 mm from beak	pv 11 bv 11	pv 11(?) bv 12	pv 13 bv 13

Description. Shell small for subgenus; valves about equally inflated; outline of shell rounded subtriangular to suboval, slightly wider than long with greatest width between one third and one half of length from apex of shell; cardinal extremities rounded; lateral margins broadly rounded; anterior commissure weakly and broadly uniplicate.

Pedicle valve strongly arched along midline over umbo and beak and more evenly and gently arched toward anterior margin, highest at about one third of length from beak; strongly arched transversely, flattened, and recurved to become gently concave toward lateral margins. Broad, very shallow, U-shaped sulcus is developed at and near anterior margin. Umbo large, highly inflated, strongly arched. Beak small, pointed, generally short, and strongly inturned. Interarea very low, narrow, round-edged laterally, orthocline to strongly anacline. Delthyrial area poorly preserved in all specimens, apparently covered by two deltidal plates, pierced apically by a fairly large, oval-shaped, mesothyridid foramen.

Brachial valve moderately arched from back to front along midline, generally accounting for slightly more than one half of total depth of shell, highest at about one half of length from beak; flanks slope steeply laterally, and are flattened, or in some specimens, concave toward lateral margins. Shallow, narrow sulcus present along midline on posterior quarter of valve, a feature common in young atrypids. Fold very low and indistinct on most specimens, developed at and near the anterior margin, forming an extended anterior margin on two specimens, and geniculate dorsally on most specimens. Beak small, strongly inturned, and hidden by opposite valve.

Both valves ornamented by very fine, radiating, round-crested costae that increase in number anteriorly by bifurcation and implantation, and are separated by rounded troughs of less or equal width. Costae very gradually increase in width anteriorly. Number of costae in 5 mm of arc at 10 mm from beaks varies from 11 to 13. Concentric growth lamellae fairly regularly spaced about 2 mm apart over most of shell, but crowded around the anterior and lateral margins.

Remarks. Desquamatia (*Independatrypa*) sp. A is informally designated because of limited material. It is obviously closely related to *D.* (*I.*) *exila* n. sp., but distinct from that species by its smaller size at maturity, subtrigonal or subquadrate outline, narrower and more inflated pedicle umbo, and narrower and more extended brachial fold.

Occurrence. Locality Ab-"11" (=GSC loc. C-136485); green, "clay-shale" bed, 1.3 m thick, uppermost Williams Island Formation; east bank of Abitibi River, immediately south of Williams Island.

Figured specimens. Hypotype ROM 47316, a relatively thick, mature adult shell with a trigonal outline; hypotype ROM 47317, a relatively thick, young adult shell with a subquadrate outline; and ROM 47318, a relatively thin, young adult shell.

Desquamatia (*Independatrypa*) sp. B

Plate 6, figures 20–29

Material. Two complete specimens, and part of a brachial valve.

Dimensions (mm) and other parameters.

Specimen	H639c-1	H639c-2
Type No.	Hypotype ROM 47319	Hypotype ROM 47320
Locality No.	Ab-"11"	Ab-"11"
Length of pv (Lpv)	13.9	14.1
Length of bv (Lbv)	13.1	13.2
Width (W)	13.0	13.4
Depth (D)	8.2	8.4
Hinge line length (Lhl)	8.9	8.6
Hinge angle (in degrees)	152	158
Depth of sulcus at anterior margin	2.4	6.1
Ratio: W/Lpv	0.94	0.95
Ratio: D/Lpv	0.59	0.56
Ratio: Lhl/W	0.68	0.64
Costae in 5 mm, 10 mm from beak	pv 10 bv 10	pv 10 bv 14

Description. Shell small for subgenus; biconvex in lateral profile, with brachial valve more inflated than opposite valve; elongate oval outline, longer than wide, width to length ratios of two specimens are 0.94 and 0.95, greatest width located about one quarter of length from beaks; cardinal extremities rounded; lateral margins broadly rounded; anterior commissure moderately to strongly uniplicate.

Pedicle valve strongly to moderately arched along midline, highest between one quarter and one third of length from beak; strongly arched transversely over midline, reversing curvature on flanks to become moderately concave toward lateral margins. Shallow, U-shaped, narrow sulcus developed on the anterior third of valve, strongly deflected dorsally and extended as a tongue in opposite valve. Umbo relatively narrow, strongly inflated, and inturned dorsally. Beak small, pointed, and extended beyond opposite valve. Interarea low, relatively narrow, round-edged laterally, orthocline to slightly anacline. Delthyrium wedge-shaped, covered by two deltidial plates, pierced apically by oval-shaped mesothyridid foramen with raised rim.

Brachial valve more highly inflated than opposite valve, accounting for two thirds or more of total depth of shell, highest near midlength of valve. Flanks slope steeply, flattened and slightly concave toward posterolateral angles. Fold rounded, relatively narrow, commonly geniculate dorsally, developed at and near the median anterior margin. Beak small, strongly inturned, and covered by opposite valve. Weak, narrow groove present along midline on apical part of valve, gradually widening anteriorly before terminating abruptly.

Exterior of both valves ornamented by very fine, radiating, round-crested costae, which increase in number anteriorly mainly by bifurcation, but also by implantation, and are separated by rounded troughs of about equal width. Number of costae in 5 mm of arc at 10 mm from beaks varies from 10 to 14 in specimens at hand.

Concentric growth lamellae are generally conspicuous, variably spaced between 1 and 2 mm apart over most of the shell, and more closely spaced and overlapping toward the lateral and anterior margins.

Remarks. This unusually thick, biconvex, small form, informally designated as *Desquamatia* (*Independatrypa*) sp. B, is distinguished from *D.* (*I.*) sp. A by its much thicker lateral profile, more pronounced unisulcate anterior commissure, and more elongate oval outline.

Desquamatia (*Independatrypa*) sp. B differs from *D.* (*I.*) *exila* n. sp. by its much smaller size at maturity, much thicker biconvex lateral profile, and narrower and deeper unisulcate anterior commissure.

Desquamatia (*Independatrypa*) *exila* n. sp., *D.* (*I.*) sp. A, and *D.* (*I.*) sp. B appear to represent three morphologically variant forms within a group that is closely similar in characters such as small size, fine costae, and development of concentric growth lamellae. Within the group, the form that most closely resembles the type species of the subgenus, *Desquamatia* (*Independatrypa*) *independensis* (Webster, 1921; Fenton and Fenton, 1935), is *D.* (*I.*) *exila* n. sp.

Occurrence. Locality Ab-"11" (=GSC loc. C-136485); green "clay-shale" bed, 1.3 m thick, uppermost Williams Island Formation; east bank of Abitibi River, immediately south of Williams Island.

Figured specimens. Hypotype ROM 47319, an elongate, oval, adult shell; and hypotype ROM 47320, a relatively thick, adult shell with a ventrally directed marginal frill.

Subfamily SPINATRYPINAE Copper, 1978

Genus *Spinatrypa* Stainbrook, 1951, p. 196

Type species. [pro *Hystricina* Stainbrook, 1945, p. 49 (*non* Malloch, 1932)] ["*Atrypa hystrix* var. *occidentalis* Hall, 1858" (errore pro *A. aspera* var. *occidentalus* Hall, 1858, p. 515) (= *A. occidentalis*, nom. transl. Stainbrook, 1938b, p. 241); OD].

Subgenus *Spinatrypa* (*Spinatrypa*) Copper, 1978, p. 298

Type species. Same as above; see Copper, 1978, p. 298.

Spinatrypa (*Spinatrypa*) sp. A

Plate 6, figures 30-35

Material. One complete specimen.

Dimensions (mm) and other parameters.

Specimen	H640a-1
Type No.	Hypotype ROM 47321
Locality No.	Ab-"11"
Length of pv (Lpv)	14.6
Length of bv (Lbv)	13.5
Width (W)	15.0
Depth (D)	5.4
Hinge line length (Lhl)	10.4
Hinge angle (in degrees)	149
Depth of sulcus at anterior margin	1.3
Ratio: W/Lpv	1.03
Ratio: D/Lpv	0.37
Ratio: Lhl/W	0.69
Costae in 5 mm, 10 mm from beak	pv 3.5 bv 3

Description. Shell small for subgenus; subovate outline; thinly biconvex in lateral profile; slightly wider than long with greatest width near midlength; hinge angle 149 degrees for single specimen; ratio of hinge line length to width of shell 0.69; front margin rounded, very slightly extended; lateral margins broadly rounded, slightly curved ventrally toward the front; anterior commissure broadly rounded, weakly and broadly uniplicate.

Pedicle valve weakly convex along midline from back to front; flattened toward cardinal extremities; flanks gently sloping, slightly convex to flat. Sulcus ill-defined, broad, and very shallow, developed at and near anterior margin of valve. Beak small, pointed, and erect. Interarea, high, relatively narrow, round-edged laterally, very slightly curved, and orthocline. Delthyrial area damaged and open; deltidial plates not apparent; foramen transversely oval-shaped, and mesothyridid.

Brachial valve gently arched along midline from back to front, highest at about one third of length from apex; slightly concave toward posterolateral angles. Flanks gently sloping, and very slightly concave. Fold weakly convex, beginning near the umbo and widening anteriorly. Umbo slightly depressed along midline. Beak small, inturned, and covered by opposite valve.

Exterior of both valves marked by relatively coarse ribs that increase in strength anteriorly; on brachial valve they increase in number by bifurcation and intercalation, and on pedicle valve they increase in number mainly by bifurcation. On the pedicle valve, a pair of dominant ribs straddle the midline, and these bifurcate twice before reaching the anterior margin. On the brachial valve, a rib occurs along the midline that originates 2.5 mm from the apex, contrasting with strong ribs on each side of the central rib that originates at the apex. Three to three and one half costae occur in 5 mm of arc at 10 mm from the beaks. Concentric growth lamellae are fairly regularly spaced over the shell, producing node-like thickenings over the ribs. Without firm evidence, one can only speculate that the node thickenings may represent remnants of spine bases.

Interiors of valves not seen.

Discussion. The informally designated *Spinatrypa* (*Spinatrypa*) sp. A from the Williams Island Formation is somewhat comparable in size, shape, lateral profile, rib strength, and rib pattern to *Spinatrypa albertensis* (Warren) as illustrated by Raasch (*in* Maurin and Raasch, 1972, Pl. 12, figs. 20–22) from the top of their Assemblage 4 (sample 504), upper Flume Formation, Kakwa Lake, British Columbia. The form from the Williams Island Formation is distinguished from that of the Flume Formation by its thinner and different lateral profile, more extended pedicle umbo and beak, higher pedicle interarea, slightly coarser and more widely spaced ribs, and central rib on the brachial valve that starts forward of the umbo rather than at the apex of the beak.

Spinatrypa (*Spinatrypa*) sp. A from the Williams Island Formation differs from "*Atrypa*" *spinosa* Hall, as described and illustrated by Branson (1922, p. 98, 99, Pl. 20, figs. 8–11; Pl. 23, figs. 8, 9) from the Snyder Creek Shale of Missouri, in having a much thinner lateral profile, finer and more widely spaced ribs, more frequent bifurcation of ribs, a central rib on brachial valve starting forward of umbo rather than at apex of beak, and a higher and more extended interarea on the pedicle valve.

Occurrence. Locality Ab-"11" (=GSC loc. C-136485); green, "clay-shale" bed, 1.3 m thick, uppermost Williams Island Formation; east bank of Abitibi River, immediately south of Williams Island.

Figured specimen. Hypotype ROM 47321, a mature adult shell.

Spinatrypa (*Spinatrypa*) *tribulosa* Norris n. sp.

Plate 6, figures 36–42; Plate 7, figures 1–18;
Figure 14

Diagnosis. *Spinatrypa* (*Spinatrypa*) with thorn-like spines on both valves, and coarse, round-crested tubular ribs that increase mainly by bifurcation on pedicle valve and mainly by intercalation on brachial valve.

Material. Nine complete specimens.

Etymology. Latin, *tribulosus*, thorny; referring to the thorn-like spines preserved on some specimens.

Dimensions (mm) and other parameters.

Specimen	H640b-1	H640b-2	H640b-3	H640b-4	H640b-5 +	H640b-6 +
Type No.	Paratype ROM 47322	Holotype ROM 47323	Paratype ROM 47324	Paratype ROM 47325	Paratype ROM 47326	Paratype ROM 47327
Locality No.	Ab-"11"	Ab-"11"	Ab-"11"	Ab-"11"	Ab-"11"	Ab-"11"
Length of pv (Lpv)	10.9	11.6	9.6	11.7	11.9	10.3
Length of bv (Lbv)	10.1	10.5	8.9	10.8	10.5	9.2
Width (W)	12.3	12.3	9.1	11.9	11.6	9.7
Depth (D)	5.7	6.2	4.2	5.2	5.7	4.2
Hinge line length (Lhl)	8.4	6.7	5.7	7.7	7.0	—
Hinge angle (in degrees)	144	143	146	159	160	—
Depth of sulcus at anterior margin	1.1	1.7	0.6	2.6	3.0	0.4
Ratio: W/Lpv	1.13	1.06	0.95	1.02	0.97	0.94
Ratio: D/Lpv	0.52	0.53	0.44	0.44	0.48	0.41
Ratio: Lhl/W	0.68	0.54	0.63	0.65	0.60	—
Ribs in 5 mm, 10 mm from beak	pv 5 bv 5	pv 5 bv 5	pv 5* bv 5*	pv 5.5 bv 5.5	pv 7.5 bv 7	pv 4 bv 5*

+ Specimens serially sectioned.
*Number of ribs measured at anterior median margin of valve.

Description. Shell very small for subgenus; subovate to subheptagonal in outline; weakly to moderately biconvex in lateral profile; generally slightly wider than

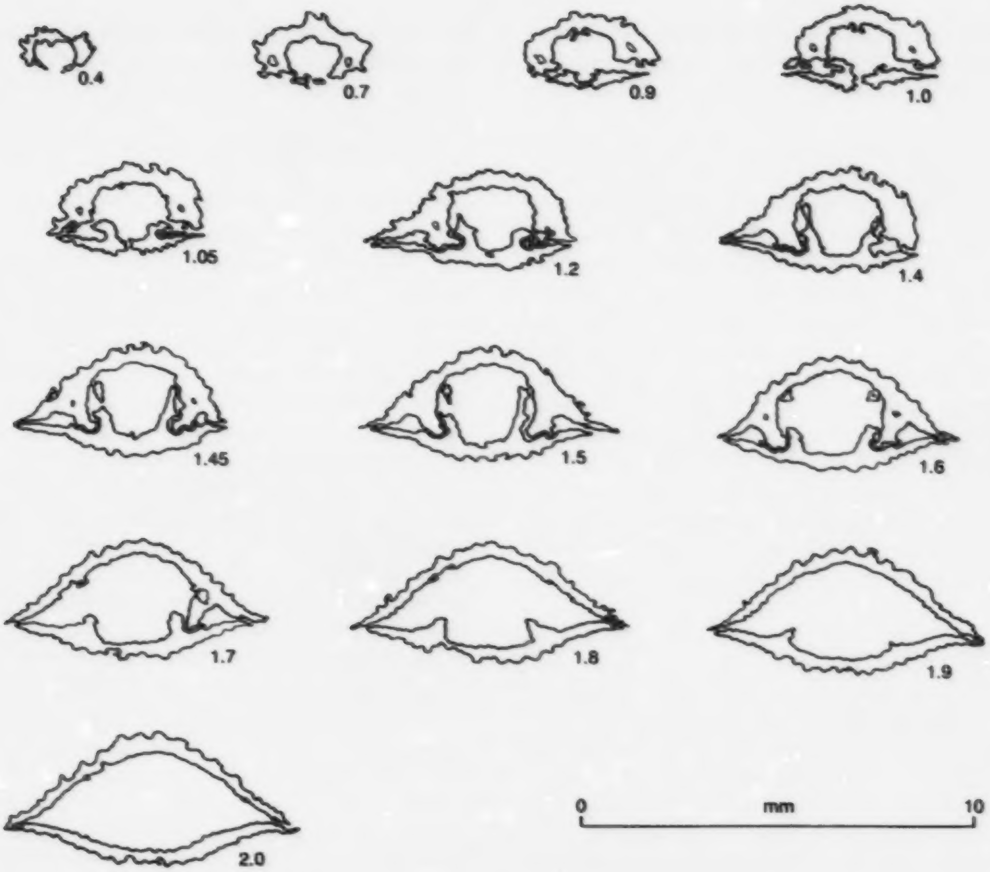


Figure 14. Transverse serial sections of a specimen of ***Spinatrypa (Spinatrypa) tribulosa*** *Norris n. sp. Distances are in millimetres forward of the beak of the pedicle valve. Paratype ROM 47327. Locality Ab-"11".*

long, rarely longer than wide, greatest width between one third and one half of length from apex. Ratio of hinge line length to width of shell varies from 0.54 to 0.68 amongst measured specimens. Lateral margins generally broadly rounded, curved ventrally toward the front; anterior margin narrowly rounded. Anterior commissure weakly and broadly uniplicate.

Pedicle valve moderately to weakly convex along midline from back to front; highest between one third and one half of length from beak; flattened and recurved toward cardinal extremities; posterolateral flanks moderately sloping, producing a flange-like extension beyond body of shell, which makes the lateral profile of the valve appear thicker. Sulcus poorly defined, broad and very shallow, developed on anterior median part of valve where it is marked by uniplicate commissure. Umbo relatively narrow, strongly inflated, and extended beyond hinge line. Beak small, pointed, and strongly inturned. Interarea high, relatively narrow, round-edged laterally, flat to slightly curved, and orthocline to slightly anacline. Delthyrium covered by two deltidial plates joined along median line; lateral junctions of deltidial plates with valve marked by finely indented lines. Foramen circular, submesothyridid, and has a narrow raised rim.

Brachial valve weakly to moderately convex along midline, highest between one quarter and one third of length from beak; posterolateral slopes mainly gently convex to flat, but curvature is reversed near margins to produce strongly concave flanges; anterolateral slopes generally gently convex. Fold weakly and broadly convex. Shallow, narrow, median trough over umbo. Beak small, inturned, covered by opposite valve.

Exterior of valves marked by round-crested, tubular ribs that are relatively fine posteriorly, gradually increasing to medium strength anteriorly; ribs increase in number by bifurcation on pedicle valve, and mainly by intercalation on brachial valve. Number of ribs in 5 mm of arc at 10 mm from the apex varies from 5 to 5.5. Ribs separated by rounded troughs generally less wide than ribs. Concentric growth lamellae fairly regularly spaced between 0.7 and 1.1 mm apart over the valves, producing thickenings over ribs, some of ribs have spine-like bases and a few ribs on flanks of valves show short, solid, prostrate spines. Fine, concentric growth lines evident between growth lamellae, and these are crossed by radial microstriae.

Interior of pedicle valve has small lateral cavities. Low, sharp-crested ridge present along midline of delthyrial cavity. Teeth relatively stout and bilobed, posteriorly projecting inwardly nearly parallel to plane of junction of valves, anteriorly projecting more dorsally obliquely. Teeth supported by very thick dental plates.

Interior of brachial valve has wide dental sockets positioned mainly on floor of valve. Crural bases and crura stout, distally becoming roughly triangular-shaped in cross-section. Spiralium not seen.

Discussion. Spinatrypa (*Spinatrypa*) *tribulosa* n. sp. is easily distinguished from the associated *Spinatrypa* (*Spinatrypa*) sp. A. by its much finer ribs, relatively thicker lateral profile, and dorsally extended posterolateral margins.

The small mature size, lateral profile, dorsally extended posterolateral margins and fine ribs of *Spinatrypa* (*Spinatrypa*) *tribulosa* n. sp. are reminiscent of *Iowatrypa americana* (Stainbrook, 1945, p. 52, Pl. 5, figs. 18–23, 27, 28, Textfig. 1 (6); Copper, 1973, p. 495, 496, Pl. 2, figs. 1–4; and Cooper and Dutro, 1982, p. 89, Pl. 24, figs. 13, 14) from the Independence Shale of Iowa. Other species of *Iowatrypa* are known from the Sly Gap Formation of New Mexico (Cooper and Dutro, 1982), Owen Member of the Hackberry Formation of Iowa (Webster, 1921; Cooper and Dutro, 1982), and the Mount Hawk Formation and equivalent beds of Western Canada (Warren and Stelck, 1956). *Spinatrypa* (*Spinatrypa*) *tribulosa* n. sp. is separated from the Iowa species by its development of spines, more strongly developed growth lamellae, slightly coarser and more widely spaced ribs, more extended pedicle beak, and by its relatively high, orthocline rather than strongly incurved, pedicle interarea.

Occurrence. Locality Ab-"11" (=GSC loc. C-136485); green, "clay-shale" bed, 1.3 m thick, uppermost Williams Island Formation; east bank of Abitibi River, immediately south of Williams Island.

Figured and/or measured specimens. Paratype ROM 47322, a relatively thick, subovate, adult shell showing spines; holotype ROM 47323, a relatively thick, adult shell; paratype ROM 47324, an elongate, subovate, young shell; paratype ROM 47325, a relatively thin, subheptagonal, adult shell showing spines; paratype ROM 47326, an elongate, young shell (serially sectioned); and paratype ROM 47327, a thin, circular, young shell (serially sectioned).

Suborder SPIRIFERIDINA Waagen, 1883

Superfamily CYRTIACEA Fredericks (1919), 1924

Family AMBOCOELIIDAE George, 1931

Genus *Emanuella* Grabau, 1923, p. 192

Type species. Nucleospira takwanensis Kayser, 1883a, p. 86; OD.

Emanuella martisoni Norris n. sp.

Plate 7, figures 19–33

Diagnosis. Emanuella with strongly convex pedicle valve, weakly convex brachial valve, rounded subpentagonal outline, rectimarginate anterior commissure, and microscopic, quincuncially arranged spine-bases covering exterior of both valves.

Material. Represented by two complete shells, one nearly complete shell, and one pedicle valve.

Etymology. Named after N.W. Martison, who in the summer of 1946 conducted a geological reconnaissance survey of the James Bay Lowland and was one of the first to make a detailed assessment of the petroleum possibilities of the area.

Dimensions (mm) and other parameters.

Specimen	H672-1	H672-2	H672-3	H672-4+
Type No.	Holotype ROM 47328	Paratype ROM 47329	Paratype ROM 47330	Paratype ROM 47331
Locality No.	Ab-"11"	Ab-"11"	Ab-"11"	Ab-"11"
Length of pv (Lpv)	7.8	5.6	10.0	7.3

Length of bv (Lbv)	6.3	4.4	—	5.9
Width (W)	8.1	5.1	>8.9	7.9
Depth (D)	5.7	3.7	4.4*	4.3
Hinge line length (Lhl)	6.0	4.6	approx. 5.5	approx. 5.8
Hinge angle (in degrees)	149	157	—	167
Ratio: W/Lpv	1.04	0.91	0.89	1.08
Ratio: D/Lpv	0.73	0.66	—	0.59
Rato: Lhl/W	0.74	0.90	0.62	0.73

*Depth of pedicle valve.
+ Not illustrated.

Description. Shell small to medium size for genus; lateral profile strongly inflated, unequally biconvex; rounded subpentagonal outline; ratio of width to length varies from 0.89 to 1.08 amongst measured specimens. Hinge line brachythyrid with rounded cardinal angles. Anterior commissure rectimarginate.

Pedicle valve highly inflated, accounting for about three quarters of total depth of shell; fairly evenly convex from back to front, highest about midlength. Posterolateral margins form angle of 92 to 96 degrees with the hinge line; anterolateral margins broadly rounded; anterior margin relatively narrow and almost straight. Umbo highly inflated. Beak bluntly rounded, considerably extended beyond opposite valve, and strongly inturned. Interarea low, relatively narrow, moderately to strongly curved, orthocline to strongly anacline toward apex, lateral borders marked by fine lines. Delthyrium relatively narrow, and bordered by fine ridges.

Brachial valve weakly to moderately inflated, highest between one third and one half of length from beak; lateral slopes flat to weakly concave. Beak small, weakly inturned. Dorsal interarea very low, separated by sharp ridges posterolaterally, very low, flat to very slightly curved, and anacline.

Exterior of both valves appears to be smooth megascopically, but under magnification, tiny, closely spaced spine-bases can be seen, best preserved where a thin outer layer of shell remains intact. Spine-bases slightly elongated longitudinally, radially and concentrically arranged to form a pattern of quincunxes. Fine, closely spaced, microscopic, concentric growth lines also evident on exterior of both valves.

Interior of pedicle cavity bordered by relatively stout dental ridges that diverge and taper anteriorly to form small teeth; some thickening evident in delthyrial cavity, but no clear evidence of a pedicle collar. Floor of valve has two relatively deep troughs starting at anterior edge of delthyrial cavity, diverging anteriorly and disappearing before reaching anterior margin of valve. Troughs separated by sharp-crested median ridge and bounded laterally by stout, broadly rounded ridges continuous with elevations on each side of delthyrial cavity. Two weakly developed troughs and ridges occur on each side of the two main ridges.

Interior of brachial valve not seen.

Discussion. Emanuella martisoni n. sp. is distinguished from *E. takwanensis* (Kayser, 1883a), the type species of the genus from the Middle Devonian of China, by its smaller size at maturity, its rectimarginate rather than weakly uniplicate anterior commissure, its more strongly inturned pedicle beak, and its different micro-ornament of radially and concentrically arranged spine-bases rather than regular concentric growth lines and indented growth lamellae, as described and illustrated by Veevers (1959b, p. 903, 904, Textfig. 3).

Emanuella martisoni n. sp. differs from *E. subumbona* (Hall) as illustrated by Cooper and Williams (1935, p. 857, Pl. 59, figs. 8, 12) from the Tully Formation of New York State in having a narrower and more elongate outline, a lower and more strongly inturned pedicle interarea, and a shorter and more steeply sloping hinge line.

Emanuella sp. described and illustrated by Cooper and Dutro (1982, p. 95, Pl. 26, figs. 1–6) from the Oñate Formation of New Mexico appears to be closely similar in size and shape to *E. martisoni* n. sp. from the Williams Island Formation. However, the Williams Island form lacks the faint and narrow mesial sinus on the pedicle valve as seen in one of the illustrations of *Emanuella* sp. (ibid., Pl. 26, fig. 6). In addition, *E. martisoni* n. sp. has a more inflated and extended pedicle umbo.

Of the numerous species of *Emanuella* described and illustrated from Devonian rocks of western and northwestern Canada by Meek (1868), Warren (1944), McCammon (1960), Norris (*in* McLaren and Norris, 1964), Crickmay (1967), and Caldwell (1968), the closest similarity of *E. martisoni* n. sp. is with *Emanuella sluzari* Crickmay (1967, p. 8, Pl. 2, figs. 20–24, Pl. 3, figs. 16–20). The latter species is recorded by Crickmay (1967, p. 8) from the *Eleutherokomma jasperensis* Zone of the Imperial et al. Faust South No. 6-2-72-11-W5 well at a depth of 6823 ft. (2097.7 m). Closely similar features of *E. martisoni* n. sp. and *E. sluzari* Crickmay are the small size, roundish outline, and rounded cardinal extremities. However, *E. martisoni* n. sp. is distinguished by its rectimarginate, rather than weakly uniplicate anterior commissure, its sloping, rather than straight, hinge line, its relatively smooth shell exterior, rather than faint and finely costellate micro-ornament that suggests assignment to the genus *Ladjia* of Veevers (1959a, p. 125), and its more robust dental ridges in the pedicle valve.

Occurrence. Locality Ab-"11" (=GSC loc. C-136485); green, "clay-shale" bed, 1.3 m thick, uppermost Williams Island Formation; east bank of Abitibi River, immediately south of Williams Island.

Figured and/or measured specimens. Holotype ROM 47328, a thick, rotund shell; paratype ROM 47329, a small, young shell; paratype ROM 47330, pedicle valve of a large, adult shell; and paratype ROM 47331, a relatively thin, small, adult shell (not illustrated).

Genus *Ladjia* Veevers, 1959a, p. 125

Type species. Ladjia saltica Veevers, 1959a, p. 126.

Ladjia? *plicata* Norris n. sp.

Plate 7, figures 34–50

Etymology. Latin, *plico, -atus, -itus*, fold; referring to the weak plications on the flanks of the pedicle and brachial valves.

Diagnosis. Ladjia? with weak plications on the flanks of both valves, unequally biconvex, with strongly inflated pedicle valve, extended and rounded cardinal extremities, parasulcate anterior commissure, endopunctate shell substance, and valve exteriors marked by vague, spine-like granules.

Material. Two complete specimens, and one crushed pedicle valve filled with marcasite.

Dimensions (mm) and other parameters.

Specimen	H672a-1	H672a-2
Type No.	Holotype ROM 47332	Paratype ROM 47333
Locality No.	Ab-"11"	Ab-"11"
Length of pv (Lpv)	7.1	6.2
Length of bv (Lbv)	5.3	4.6
Width (W)	9.2	6.5
Depth (D)	4.0	3.9
Ratio: W/Lpv	1.30	1.05
Ratio: D/Lpv	0.56	0.63
Plicae on flanks of shell	pv 5-5 bv 4-4	pv 3-3 bv 3-3

Description. Shell small for genus; unequally biconvex, almost planoconvex, pedicle valve having much greater depth and convexity; cardinal extremities conspicuously extended and rounded at tips; wider than long with greatest width along straight hinge line; lateral commissures nearly straight; anterior commissure parasulcate.

Pedicle valve very much larger and more convex than opposite valve; strongly and regularly arched from back to front; more strongly arched transversely over medial part of valve and reversing curvature to become concave toward cardinal extremities; highest part of valve at or a little less than midlength from beak. Sulcus originating over beak, very shallow, rounded bottom, gradually widening and deepening anteriorly, and extended as a rounded tongue in opposite valve. Umbo and beak form an angle of between 63 and 74 degrees, and are considerably extended beyond hinge line. Interarea triangular-shaped, relatively high, delineated laterally by rounded beak ridges, evenly curved, apsacline toward hinge line and anacline toward beak. Delthyrium narrow, open; upturned edges of delthyrium near hinge line of one specimen suggest that it may have been partly covered by a convex deltidium.

Brachial valve very gently convex in umbonal region, almost flat posterolaterally toward cardinal extremities and laterally on flanks, except for coarse plications. Fold originates on umbo, and is low, broadly convex, slightly elevated above flanks, and bordered anteriorly by shallow, rapidly widening grooves. Umbo low, broadly and weakly convex. Beak small, very slightly extended beyond hinge line. Interarea vey low, highest beneath beak, diminishing in height laterally to a line of junction, slightly curved, and orthocline. Notothyrium not clearly evident, appears to be broad and low.

On anterior parts of flanks of pedicle valve of larger specimen, there are five, broad, very weak plications, and on smaller specimen there are three. On flanks of brachial valve plications stronger and more conspicuous: four on larger and three on smaller specimen. Plications on each side of median fold are strongest, originating over umbo, separated from fold anteriorly by diverging shallow troughs. Remaining plicae much weaker, diminishing in strength laterally.

Exterior of shell marked by tiny, vague, spine-like granules, preserved only on protected parts of valves. Also present are faint, closely spaced, radial markings. Growth lamellae irregularly spaced and weakly imbricate. Shell substance has fine, closely spaced endopunctae, conspicuously marked by opaque dark substance, possibly iron oxide. Pedicle interarea marked by fine, irregularly spaced, transverse striations.

In apical part of open delthyrium of pedicle valve can be seen a knife-like median septum, which in one specimen is separated along the midline into two parts. Septum is analogous to that present in cyrtinids.

Interior of brachial valve not seen.

Remarks. The combination of characters exhibited by this form appears to be new. However, it most closely complies with the generic diagnosis by Veevers (1959a, p. 125) for *Ladjia*, which is as follows: "Ambocoeliinae with radiating costellae, ventral sulcus and dorsal fold alternate". Some of its characters are also suggestive of the genus *Thomasaria* Stainbrook (1945), and the genus *Echinocoelia* Cooper and Williams (1935).

Comparison. Ladjia? *plicata* n. sp. is distinguished from *L. saltica* Veevers (1959a, p. 126–128, Pl. 12, figs. 1–29, Textfigs. 76–78), the type species of the genus from Frasnian rocks of the Fitzroy Basin of Western Australia, by the extended cardinal angles, weakly plicate flanks, parasulcate anterior commissure, and a median septum rather than a medial ridge in the delthyrial cavity of the pedicle valve.

Ladjia? *plicata* n. sp. bears some similarity to *Thomasaria rockymontana* (Warren, 1928) as redescribed and illustrated by Crickmay (1967, p. 9, 10, Pl. 2, figs. 42–44, Pl. 3, figs. 22–24) from basal Minnewanka Group or equivalents of the Perdrix Formation, at east end of Crowsnest Lake (49°38′N, 114°38′W), Alberta. *Ladjia*? *plicata* n. sp. is distinguished from *T. rockymontana* by its more rounded and inflated pedicle umbo, narrower and shallower pedicle sulcus, lower and more inturned pedicle interarea, and extended, rather than rounded, cardinal extremities. A feature not mentioned by either Warren (1928) or Crickmay (1967) for *T. rockymontana* is the presence of faint plications on the flanks of the pedicle valve that can be seen on a syntype illustrated by Crickmay (1967, Pl. 3, figs. 23, 24).

Ladjia? *plicata* n. sp. differs from *L. landesi* Crickmay (1967, p. 9, Pl. 2, figs. 25–29, Pl. 3, figs. 10–15) described from the lower part of the lower member of the Swan Hills Formation (Slave Point Formation equivalent) in the subsurface of northern Alberta in several conspicuous features such as a planoconvex lateral profile, extended cardinal extremities, and a parasulcate anterior commissure. Crickmay (1967, p. 9) pointed out that *L. landesi* lacks "micro-spinule bases".

Ladjia? *plicata* n. sp. is distinguished from *L. utahensis* (Beus, 1965, p. 27, Pl. 10, figs 1–9, Textfigs. 4A, B) from the lower Jefferson Formation at sections in Utah and Idaho by the same characters that separate it from *L. landesi*.

The finer surface markings of *L.*? *plicata* n. sp. are clearly distinct from those of *Echinocoelia* Cooper and Williams (1935). Species of the latter genus are characterized by concentric lamellae, each bearing a single row of fine, short, simple spines.

Occurrence. Locality Ab-"11" (=GSC loc. C-136485); green, "clay-shale" bed, 1.3 m thick, uppermost Williams Island Formation; east bank of Abitibi River, immediately south of Williams Island.

Figured specimens. Holotype ROM 47332, a wide, mature adult shell; and paratype ROM 47333, an elongate, young adult shell.

Superfamily CYRTINACEA Frederiks, 1912

[nom. transl. Johnson, 1966 (ex CYRTININAE Frederiks, 1912)]

Family CYRTINIDAE Frederiks, 1912

Genus *Cyrtina* Davidson, 1858, p. 66

Type species. [*Calceola heteroclita* Defrance, 1828, p. 306; SD Hall and Clarke, 1894, p. 44] [= *Spinocyrtina* Frederiks, 1916, p. 18 (type *Cyrtia hamiltonensis* Hall, 1857); *Cyrtinaellina* Frederiks, 1926, p. 414 (type, *Cyrtina acutirostris* Shumard, 1855)].

Cyrtina sp. aff. *C. triquetra* (Hall)

Plate 8, figures 1–28; Figure 15

Material. Eight complete specimens.

Dimensions (mm) and other parameters.

Specimen	H678-1	H678-2	H678-3	H678-4*	H678-5*
Type No.	Hypotype ROM 47334	Hypotype ROM 47335	Hypotype ROM 47336	Hypotype ROM 47337	Hypotype ROM 47338
Locality No.	Ab-"11"	Ab-"11"	Ab-"11"	Ab-"11"	Ab-"11"
Length of pv (Lpv)	8.9	7.5	6.1	7.1	7.4
Length of bv (Lbv)	6.6	5.5	5.0	6.1	5.3
Width (W)	8.9	6.5	6.8	9.0	6.9
Depth (D)	6.0	5.0	4.7	6.5	5.6
Ratio: W/Lpv	1.00	0.87	1.11	1.27	0.93
Ratio: D/Lpv	0.67	0.67	0.77	0.92	0.76
Costae on flanks	pv 8-8 bv 8-8	pv 7-8 bv 7-6	pv 8-7 bv 7-7	pv 7-7 bv 7-6	pv 5-5 bv 5-5

*Specimens serially sectioned.

Description. Shell small for genus; unequally biconvex; subhemielliptical in dorsal view; subpyramidal in lateral view; widest along or very near hinge line, width varying from less than, to greater than, length of pedicle valve; cardinal angles sharply angular to gently rounded; lateral margins nearly straight, slightly deflected ventrally toward anterior margin in some specimens; anterior commissure uniplicate.

Pedicle valve strongly subpyramidal, highest at beak, accounting for most of total depth of shell. Beak ridges from beak to cardinal angles gently concave. Flanks steep and gently convex anterolaterally. Sulcus originating over beak and gradually widening anteriorly; relatively shallow, rounded V-shaped in cross-section, extended as short tongue in opposite valve. Distinct groove along midline of sulcus in most specimens. Interarea is triangular-shaped, bounded by round-edged beak ridges, very high, slightly to moderately curved, catacline, changing to apsacline toward beak; twisted to one side in some specimens. Delthyrium narrow, triangular-shaped, largely covered by an externally convex deltidium, pierced by an elongate foramen toward beak. Length of foramen between one quarter and one third of height of interarea.

Brachial valve weakly inflated, highest about one third of length from beak, gently concave toward hinge line and cardinal angles. Lateral flanks sloping gently, flat to gently convex. Fold originating at beak, low and broadly rounded, with faint trace of medial groove on some specimens. Beak small, inconspicuous, inturned, and very slightly extended beyond hinge line. Interarea covered by opposite valve beneath beak, very low on each side of beak, diminishing in height laterally to become a line of junction, and orthocline.

Flanks of shell covered with 6 to 8 costae that increase in strength anterolaterally; in cross-section they are low and rounded and separated by shallow, U-shaped interspaces. On pedicle valve of most specimens costae originate anterior of the umbo and beak ridges. On brachial valve they originate on each side of fold along cardinal margin. Costae flanking sulcus and fold are by far strongest and most conspicuous; those flanking dominant costae are narrower and lower and diminish in size laterally.

Microscopic, quincuncially arranged, tear-shaped granules evident on parts of shell exterior. Concentric growth lines and short growth lamellae preserved on some specimens. Interareas show fine longitudinal and transverse markings, the latter of unequal strength and irregular spacing, suggesting growth lines. Shell substance endopunctate.

Interior of pedicle valve has a long, high, blade-like median septum to which short, convergent dental plates are joined. A small chamber, the tichorhinum, formed by lateral struts joining extended median septum and inner dental plates. A deltidium partly covers delthyrium between distal ends of dental plates. Teeth small, directed obliquely inward toward plane of symmetry.

Interior of brachial valve has small dental sockets between floor of valve and inner socket ridges.

Comparison. In small size, overall shape, number of costae on flanks, and the presence of medial grooves on both the fold and sulcus, the form from the Williams Island Formation most closely resembles *Cyrtina triquetra* (Hall) as described and illustrated by Stainbrook (1943b, p. 446, 447, Pl. 70, figs. 22–29) from the Cedar Valley Limestone of Iowa, where it occurs most abundantly in the *waterlooensis* Zone. *Cyrtina triquetra* has been described also by Griesemer (1965, p. 288, Pl. 6, figs. 7–9) from the Lindwurm and Berthlet members of the Milwaukee Formation of Wisconsin. However, the presence of spine-like granules on the exterior of the Williams Island form appears to distinguish it from *C. triquetra*, but it is uncertain if this is a diagnostic feature or is evident

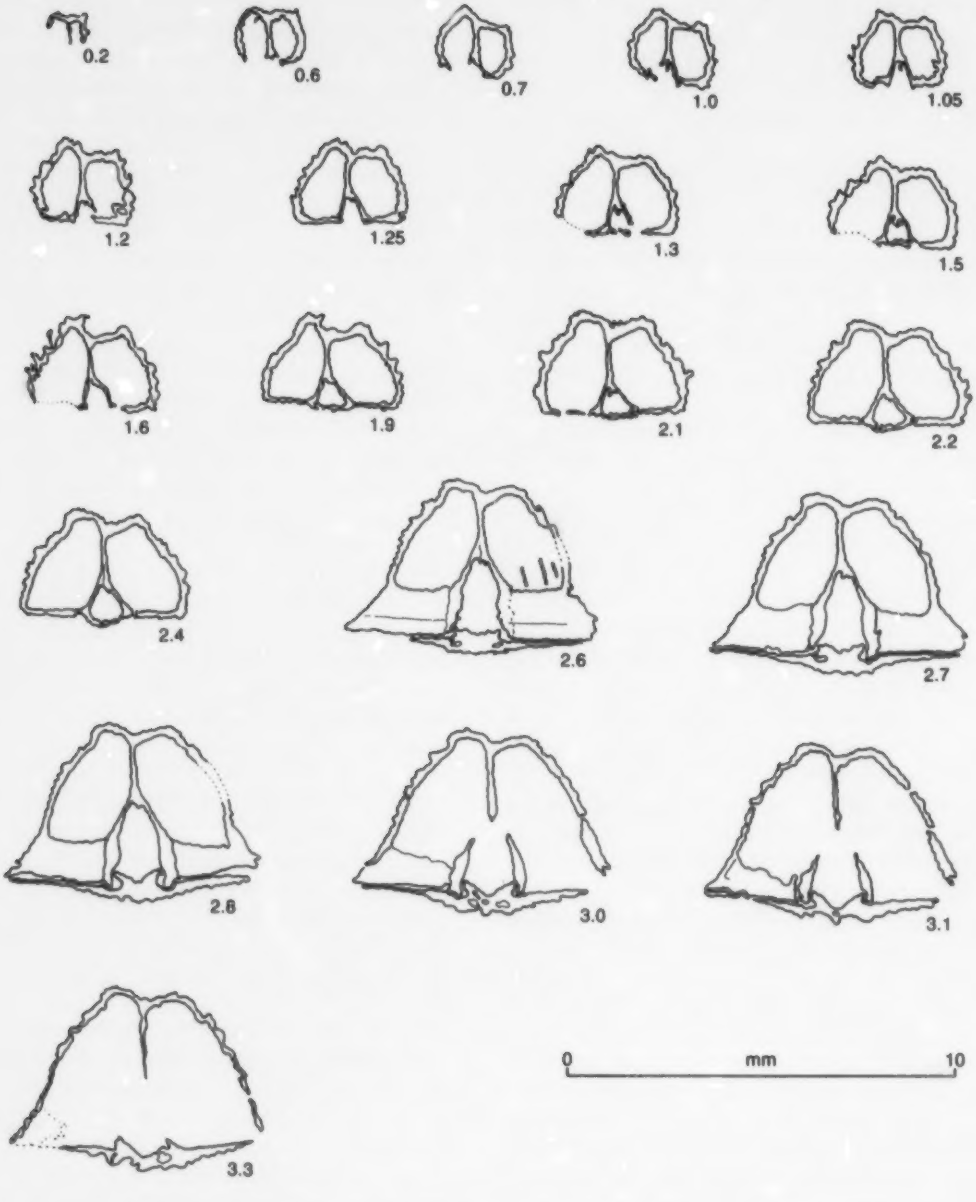


***Figure 15.** Transerve serial sections of **Cyrtina** sp. aff. **C. triquetra** (Hall). Distances are in millimetres forward of the beak of the pedicle valve. Hypotype ROM 47338. Locality Ab-"11".*

only under special conditions of preservation. In the original description of *Cyrtina triquetra* Hall (1858, p. 513, 514), the surface of the shell was referred to as "granulose or punctate".

The northern Ontario form also has similar features to *Cyrtina hamiltonensis* (Hall, 1867, p. 268, 269, Pl. 54, figs. 26–33) from the Hamilton Group of New York State, which include small size, overall shape, number of costae on flanks (6–8), and presence of spine-like granules. It differs from the New York form by having a distinct medial groove in the sulcus of the pedicle valve and a weakly developed medial groove on the fold of the brachial valve.

Cyrtina staufferi Wright and Wright (1963, p. 128, 129, Pl. 2, figs. 1-15) described from the upper Ipperwash Limestone, Hamilton Group, of the Ipperwash-Kettle Point region of southwestern Ontario, is another form that has a number of features in common with the form from northern Ontario. The northern Ontario form is distinguished from *C. staufferi* by its smaller size, fewer costae on the flanks (6-8 versus 6-10), and absence of two diverging lines radiating from the beak of the pedicle interarea. The latter feature can be seen on two illustrated specimens of *C. staufferi* Wright and Wright (1963, Pl. 2, figs. 4, 11) and is, presumably, a consistent character for the species.

In small size and development of costae, the form from northern Ontario bears some resemblance to *Cyrtina caroline* Johnson (1978, p. 131, Pl. 8, figs. 1-31) from the *hippocastanea* Zone (Interval 25) and *Choperella* fauna (Interval 26) of central Nevada. The northern Ontario form is distinguished by its more regular and symmetrical outline, its conspicuously wider fold on the brachial valve, its wider sulcus on the pedicle valve, and its less pointed and less extended pedicle beak.

Occurrence. Locality Ab-"11" (=GSC loc. C-136485); green, "clay-shale" bed, 1.3 m thick, uppermost Williams Island Formation; east bank of Abitibi River, immediately south of Williams Island.

Figured and/or measured specimens. Hypotype ROM 47334, a mature adult shell; hypotype ROM 47335, a young, narrow, elongate shell; hypotype ROM 47336, a young, wide shell; hypotype ROM 47337, a young adult shell (serially sectioned); and hypotype ROM 47338, a young adult shell (serially sectioned).

Genus *Tecnocyrtina* Johnson and Norris, 1972, p. 566

Type species. Cyrtina billingsi Meek, 1868, p. 97.

Tecnocyrtina bicostata Norris n. sp.

Plate 8, figures 29-50; Plate 9, figures 1-7; Figure 16

Diagnosis. Tecnocyrtina with two low, broad costae on the fold of the brachial valve and on the sulcus of the pedicle valve; with six to eight costae on the flanks of the valves; and with shell surface marked by quincuncially arranged, microscopic, tear-shaped or spine-like granules.

Material. 12 complete specimens.

Etymology. Latin, *bi-*, two, double; *costatus*, ribbed; referring to the two costae on the fold and sulcus.

Dimensions (mm) and other parameters.

Specimen	H678a-1	H678a-2	H678a-3	H678a-4*	H678-5*
Type No.	Paratype ROM 47339	Holotype ROM 47340	Paratype ROM 47341	Paratype ROM 47342	Paratype ROM 47343
Locality No.	Ab-"11"	Ab-"11"	Ab-"11"	Ab-"11"	Ab-"11"
Length of pv (Lpv)	9.8	8.3	8.4	8.5	8.3
Length of bv (Lbv)	7.0	6.8	5.9	6.4	6.7
Width (W)	9.6	8.8	7.8	8.0	9.1
Depth (D)	6.3	6.3	5.4	6.6	5.7
Ratio: W/Lpv	0.98	1.06	0.92	0.94	1.10
Ratio: D/Lpv	0.64	0.76	0.64	0.78	0.69
Costae on flanks	pv 7-7 bv 7-6	pv 7-8 bv 8-7	pv 6-6 bv 6-6	pv 5-6 bv 6-5	pv 7-7 bv 7-6
Costae in sulcus of pedicle valve	2	2	2	2	2
Costae on fold of brachial valve	2	2	2	2	2

*Specimens serially sectioned.

Description. Shell small for genus. Lateral outline of pedicle valve highly inflated and hemipyramidal; that of brachial valve gently convex to nearly flat. Maximum width of shell at or slightly anterior of cardinal angles, varying from slightly less to slightly greater than length of pedicle valve. Cardinal angles generally close to a right angle, but in some specimens slightly extended and acute. Posterior parts of lateral commissures straight and nearly parallel; curving anteriorly toward midline. Anterior margin rounded. Anterior commissure uniplicate.

Pedicle valve highly inflated, subpyramidal, highest between 2.2 and 2.9 mm from beak, accounting for most of total depth of shell; strongly arched over beak and umbo, and moderately arched anteriorly. Flanks steeply sloping and gently convex. Sinus originates over umbo and widens and deepens anteriorly; shallow, and rounded V-shaped in cross-section, slightly extended as

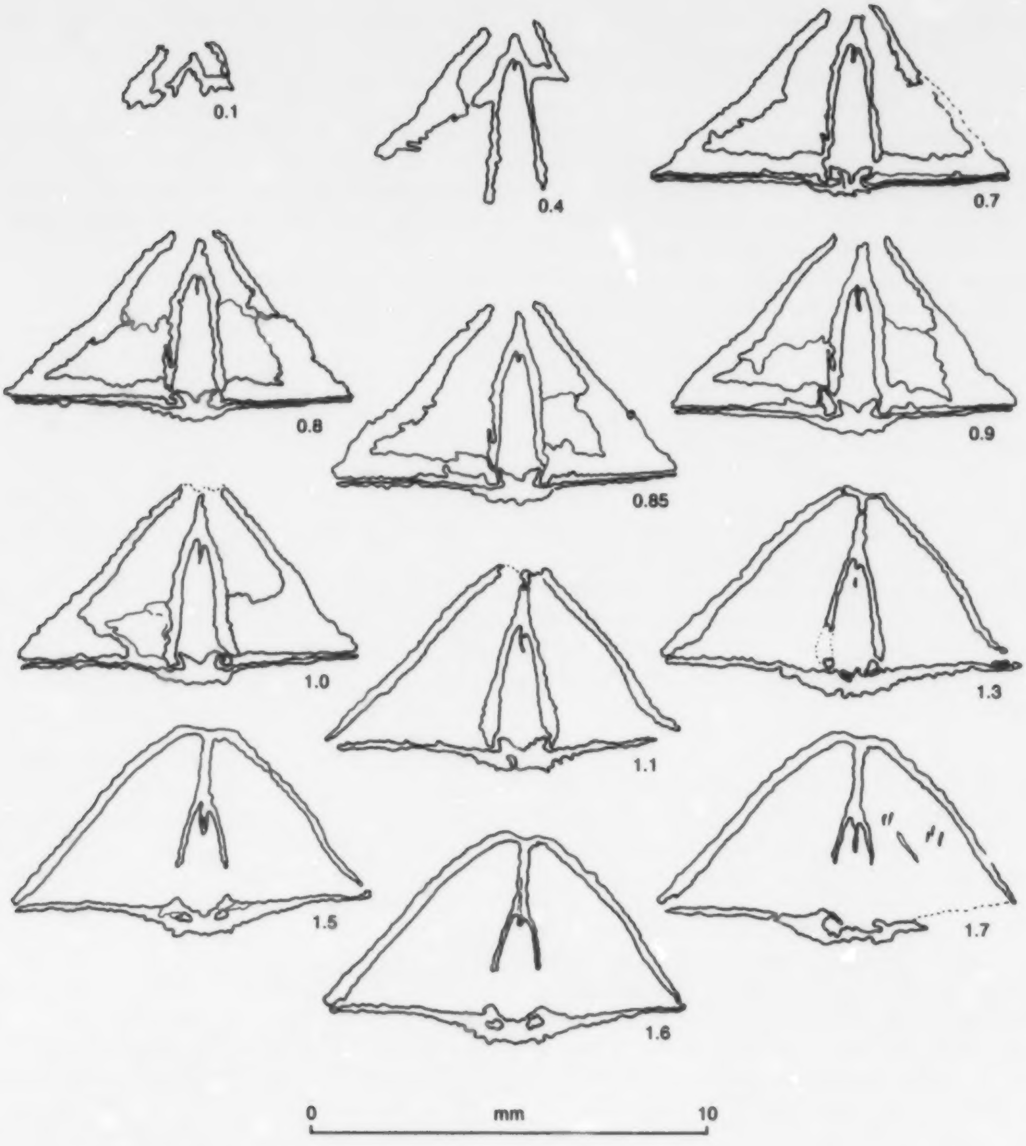


*Figure 16. Transverse serial sections of a specimen of **Tecnocyrtina bicostata** Norris n. sp. Distances are in millimetres forward of the beak of the pedicle valve. Paratype ROM 47343. Locality Ab-"11".*

broadly rounded, short tongue in opposite valve. Within sulcus is a weak but distinctive median groove, with two very weak, variably developed costae straddling the groove. Interarea is triangular-shaped, sharply bounded laterally by beak ridges, very high, flat, and catacline toward hinge line, and curved and apsacline toward beak. Interarea commonly twisted to left or right. Delthyrium narrow and triangular-shaped, partly covered by raised externally convex deltidium, which is pierced by an elongate foramen toward beak. Foramen occupies between one third and four fifths of maximum height of interarea. Beak acute and strongly incurved.

Brachial valve weakly inflated, highest along midline at about one fifth of length from beak.

Posterolateral flanks gently concave, anterolateral flanks gently convex; in a few specimens lateral and anterior parts of valve have reversed curvature, producing a concave flange. Fold originates over beak and widens gradually for part of its length and then flares out on anterior third of valve to produce an irregular trumpet-shaped outline; in cross-section sulcus is shallow and broadly rounded. Two broad plications occur on fold, separated by a shallow medial groove. Beak is very small and slightly extended beyond hinge line. Interarea very low, flat, orthocline, highest beneath beak, and reduced to lines of junction laterally. Interarea beneath beak largely covered by a raised, convex deltidium of opposite valve.

Flanks of shell have from 6 to 8 costae that increase in strength anteriorly and diminish in size laterally. In cross-section costae are low and rounded, separated by shallow, U-shaped interspaces. Costae marking sides of fold and sulcus conspicuously wider, originating over umbones; flanking costae of pedicle valve originate along and near beak ridges, those of brachial valve originate along cardinal margin.

Shell surface, including interareas, marked by quincuncially arranged, microscopic, tear-shaped or spine-like granules. These seem to be most evident on parts of the shell surface that have been subjected to a slight amount of abrasion or weathering. Shell surface marked also by unevenly spaced, fine, concentric growth lines and lamellae. Interareas marked with fine, irregularly spaced, transverse growth lines. Shell substance has very fine, closely spaced endopunctae.

Interior of pedicle valve has a long, blade-like median septum to which high, convergent dental plates are joined; septum extends slightly beyond the junction dorsally. Small tichorhinum along median septum near apex of beak. Small teeth, projecting obliquely inward, attached to distal ends of dental plates.

Interior of brachial valve has small dental sockets on socket plates; separated from floor of valve by lateral cavities. Inner socket ridges curve laterally to overhang dental sockets.

Comparison. *Tecnocyrtina bicostata* n. sp. is distinguished from *T. missouriensis* (Swallow) as described and illustrated by Branson (1922, p. 108, Pl. 16, fig. 9, Pl. 19, figs. 1–4), Stainbrook (1943b, p. 447, 448, Pl. 70, figs. 6–11), and Johnson and Norris (1972, Pl. 1, figs. 5–18) from the *waterlooensis* Zone of the Rapid Limestone of the Cedar Valley Formation of Iowa, and the Callaway Member of the Cedar Valley Formation of Missouri, by its smaller size, fewer costae on the flanks—6 to 8 versus 6 to 10—and much weaker development and fewer costae on the sulcus and fold—2 versus 2 to 4.

Tecnocyrtina bicostata n. sp. is closely similar to the *Cyrtina* sp. cf. *C. missouriensis* of Raasch (*in* Maurin and Raasch, 1972, p. 63, 64, Pl. 3) from their Assemblage II, collected from two levels (samples 454 and 459) of the lower Flume Formation, Wallbridge Mountain section, British Columbia. *Tecnocyrtina bicostata* n. sp. is distinguished from the Wallbridge Mountain form by its differently shaped, lower pedicle interarea—catacline to apsacline versus procline to apsacline; higher and more conspicuous fold on the brachial valve; and weaker and fewer costae on the fold and sulcus. The Wallbridge Mountain form has three costae on the fold and two costae in the sulcus. Like *T. bicostata* n. sp., it also has the microscopic, spine-like granules on the shell exterior.

The form from Wallbridge Mountain was later described as *Tecnocyrtina missouriensis raaschi* by Johnson and Trojan (1982, p. 131, Pl. 7, figs. 1-5). They pointed out that *T. m. raaschi* is distinguished from *T. m. missouriensis* from Bellamy Springs, Missouri, by its relatively broader outline.

Occurrence. Locality Ab-"11" (=GSC loc. C-136485); green "clay-shale" bed, 1.3 m thick, uppermost Williams Island Formation; east bank of Abitibi River, immediately south of Williams Island.

Figured and/or measured specimens. Paratype ROM 47339, a large, elongate, adult shell; holotype ROM 47340, a wide, adult shell; paratype ROM 47341, a small, elongate shell; paratype ROM 47342, a medium, elongate shell (serially sectioned); and paratype ROM 47343, a wide, adult shell (serially sectioned).

Superfamily SPIRIFERACEA W. King, 1846

Family MUCROSPIRIFERIDAE Boucot, 1959b
emend. Carter, 1972

Genus *Mucrospirifer* Grabau, 1931, p. 408

Type species. *Delthyris mucronata* Conrad, 1841, p. 54; OD. [= *Lamellispirifer* Nalivkin, 1937, p. 87, obj.].

Remarks. The generic characters separating *Mucrospirifer* Grabau, 1931, from the Middle Devonian of eastern North America, and *Eleutherokomma*

Crickmay, 1950, from younger Devonian rocks of western North America, are exceedingly close. The complex micro-ornament on *Eleutherokomma* was considered by Crickmay (1950, p. 220) to be a diagnostic feature separating it from *Microspirifer*. However, examination of many specimens suggests that the micro-ornament of both genera is essentially similar, if not identical. Descriptions and illustrations of the micro-ornament for *Mucrospirifer* by Tillman (1964, p. 958, Pl. 154, fig. 1) and for *Eleutherokomma* by Crickmay (1953, p. 3, Pl. 2, fig. 6) and by Norris *in* Norris and Uyeno (1983, p. 34, Pl. 8, figs. 1, 4) support this conclusion.

The lack of micro-ornament on the exterior of the shell and absence of a myophragm in the ventral valve of *Mucrospirifer parvus* Cooper and Dutro (1982, p. 97) were apparently the main criteria used by these authors for assigning this species to *Mucrospirifer* rather than *Eleutherokomma*. However, a thin, sharp or blunt median ridge (myophragm) is present in the pedicle valve of some species of both *Mucrospirifer* and *Eleutherokomma*. This feature is illustrated by Tillman (1964, Pl. 153, fig. 6) for *Mucrospirifer prolificus* (Stewart) from the lower part of the Silica Formation, Lucas County, Ohio, and described by Crickmay (1950, p. 219, 220) for *Eleutherokomma hamiltoni* Crickmay from the Waterway Formation of northeastern Alberta. This feature is also clearly evident in the interior of the pedicle valve of *Mucrospirifer cooperi* Wright and Wright (1963, Pl. 2, fig. 26) from the upper Ipperwash Limestone, Hamilton Group, Ipperwash-Kettle Point region, southwestern Ontario.

Carter (1972, p. 734) in his investigation of some of the lamellose spiriferacean brachiopods pointed out that internally both *Mucrospirifer* and *Eleutherokomma* have dental adminicula.

Mucrospirifer williamsi Norris n. sp.

Plate 9, figures 8-37; Figure 17

Diagnosis. *Mucrospirifer* of small size and relatively narrow width for the genus, slightly extended cardinal extremities, and with five to eight costae on the flanks of the valves.

Material. Seven complete specimens, four incomplete pedicle valves, and one incomplete brachial valve.

Etymology. Named for M.Y. Williams whose early work (Williams, 1920) in the Moose River Basin prompted Kindle (1924, p. 35) to name Williams Island in Abitibi River and the Williams Island Formation after him.

Dimensions (mm) and other parameters.

Specimen	H686-1	H686-2	H686-3	H686-4	H686-5	H686-6*	H686-7*
Type No.	Paratype ROM 47344	Holotype ROM 47345	Paratype ROM 47346	Paratype ROM 47347	Paratype ROM 47348	Paratype ROM 47349	Paratype ROM 47350
Locality No.	Ab-"11"	Ab-"11"	Ab-"11"	Ab-"11"	Ab-"11"	Ab-"11"	Ab-"11"
Length of pv (Lpv)	7.3	7.5	6.6 est.	7.9+	—	6.0	6.5
Length of bv (Lbv)	6.5	6.8	—	—	5.1+	5.1	5.2
Width (W) (excl. c.e.)	11.3	10.0	7.8	13.0 est.	—	8.7	8.1
Width (Whl) (incl. c.e.)	13.2	10.5	—	—	—	10.2	8.8
Depth (D)	4.8	5.6	—	—	—	4.8	4.4
Ratio: W/Lpv	1.55	1.33	1.18	1.65	—	1.45	1.35
Ratio: D/Lpv	0.66	0.75	—	—	—	0.80	0.68
Ratio: Whl/W	1.17	1.05	—	—	—	1.05	1.09
Costae on flanks	pv 7-8 bv 8-8	pv 6-6 bv 5-5	pv 5-5 bv —	pv 7-8 bv —	pv — bv 5-5	pv 6-6 bv 5-6	pv 6-6 bv 6-6

*Specimens serially sectioned
excl.c.e. = excluding cardinal extensions
incl.c.e. = including cardinal extensions

Description. Shell small and relatively narrow for genus. Ratio of width to length of pedicle valve varying between 1.18 and 1.65 for measured specimens. Shape subsemicircular to subsemielliptal, with slightly extended cardinal extremities. Lateral profile unequally biconvex. Hinge line straight, marking greatest width of shell. Lateral commissures zig-zag where coarse costae alternate; anterior commissure very slightly indented and uniplicate.

Pedicle valve moderately convex, accounting for about two thirds of total depth of shell, highest at about one third of length from beak. Posterolateral slopes have curvature reversed, becoming slightly to moderately concave. Anterolateral slopes are relatively steep and nearly flat. Beak small and moderately extended beyond opposite valve. Interarea highest beneath beak, but laterally of low, uniform height to cardinal angles; slightly curved and apsacline.

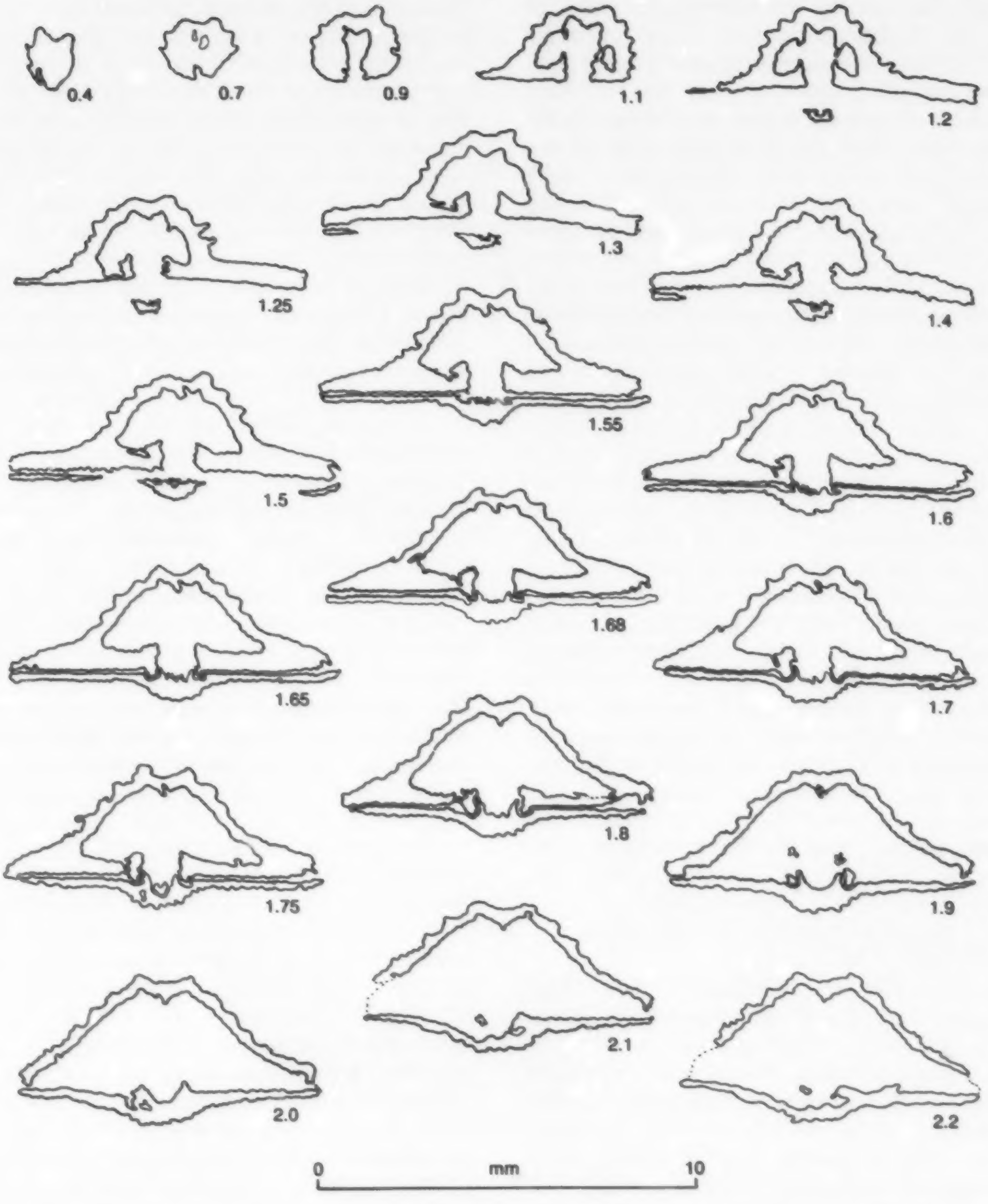


Figure 17. Transverse serial sections of a specimen of ***Mucrospirifer williamsi*** *Norris n. sp. Distances are in millimetres forward of the beak of the pedicle valve. Paratype ROM 47350. Locality Ab-"11".*

Delthyrium triangular-shaped with straight lateral borders. Recessed plates on each side of delthyrium meet at apex to form circular foramen. Plates appear continuous with inner side of dental plates that extend to floor of valve. Sulcus originates over umbo and expands anteriorly at an angle of about 25 degrees; it is broadly U-shaped with subangular edges, steep-sided, with flattened floor, except for a faint to prominent medial ridge originating about one third of length from beak; sulcus extended as tongue in opposite valve. Costae forming sides of sulcus are widest and most conspicuous on valve.

Brachial valve weakly to moderately convex in lateral profile, highest about one quarter of length from beak; broadly convex medially in anterior profile, with flanks becoming gently concave laterally. Fold originates on beak where it is very narrow and rapidly widens anteriorly. Beak has steep sides and flat top except for a faint medial groove extending entire length of fold on most specimens. Beak and umbo very small, beak projecting slightly beyond hinge line. Interarea very low, highest beneath beak; laterally of uniform height to cardinal extremities; flat and orthocline throughout most of its height, but curves near beak to become anacline. Part of longitudinally striated cardinal process can be seen beneath beak in one specimen.

Flanks of both valves on each side of fold and sulcus marked with from 5 to 8 relatively coarse costae that become progressively narrower laterally; costae and intercostal furrows gradually increase in strength anteriorly; V-shaped in cross-section with rounded apices. Entire surface of shell, except interarea, covered with relatively coarse and closely spaced concentric growth lamellae. Lamellae covered with fine, radial capillae, crossed by fine, concentric growth lines of about the same size, producing a finely reticulate pattern seen under magnification.

Interarea of both valves has fine, irregularly and closely spaced growth lines parallel to hinge margin, crossed by fine, closely spaced longitudinal markings at a slightly oblique angle to hinge margin.

Interior of pedicle valve has long, straight, hinge teeth attached to distal ends of dental plates. Dental plates stout and short, extending anteriorly less than one fifth of length of valve, diverging strongly from floor of valve, and diverging from beak parallel to first troughs flanking sulcus on valve exterior. A broad myophragm with a sharp crest occurs along midline in posterior third of valve; in remaining anterior two thirds of valve this ridge-like structure is round-crested. Sulcus, costae, and intercostal furrows strongly impressed on interior of valve. Muscle scars and genital markings not apparent.

Interior of brachial valve has small dental sockets on fulcral plates separated from floor of valve by small cavities. Strong crura form inner wall of sockets, tilted laterally, slightly overhanging sockets. Cardinal process between traces of crura longitudinally striated; anteriorly, cardinal process gives way to callus deposits extending to floor of valve.

Remarks. In the collection at hand, two variants are present, a narrow form (form A) represented by seven specimens, and a wider form (form B) represented by four specimens. Because of the difficulty of assessing the consistency of two closely related forms in a limited collection, they are here treated as a single species.

A new type of delthyrial cover, referred to as a stegidial plate, was described and illustrated by Cowen (1968) from well preserved specimens of *Mucrospirifer mucronatus* (Conrad) from the Middle Devonian Traverse Group of Michigan. These unusual plates are not evident on any of the specimens of *Mucrospirifer williamsi* n. sp.

Comparison. On features such as small size and relatively narrow width, *Mucrospirifer williamsi* n. sp. is closely comparable to *Mucrospirifer norwoodensis* Tillman (1964, p. 963, 964, Pl. 15, figs. 39–44) from the upper part of the Petoskey Formation, Charlevoix County, Michigan. *Mucrospirifer williamsi* n. sp. differs in being considerably smaller at maturity, in having a weak median ridge in the sulcus of the pedicle valve and a weak median groove on the fold of the brachial valve, in having more extended cardinal extremities, in being proportionately wider, especially for form B, and in having fewer costae on the flanks of the shell, 5 to 8 compared to 9 to 11 for *M. norwoodensis*.

The narrower variant (form A) of *Mucrospirifer williamsi* n. sp. bears some resemblance in very small size and shape to *Allanella minutilla* Crickmay (1953, p. 7, Pl. 1, figs. 13–22), which occurs typically in the topmost bed of the Maligne Formation at cold Sulphur Spring, 19.5 km north of Jasper, Alberta. *Mucrospirifer williamsi* n. sp. is distinguished by its much lower interarea on the pedicle valve, much smaller and less prominent brachial umbo and beak, and slightly extended, mucronate cardinal extremities rather than rounded cardinal angles. All specimens of *M. williamsi* n. sp. display a median groove on the fold of the brachial valve, but this feature is present only in some specimens of *Allanella minutilla*, as illustrated by Circkmay (1953, Pl. 1, figs. 17, 19).

The wider variant (form B) of *Mucrospirifer williamsi* n. sp. is closely comparable to *Eleutherokomma jasperensis* (Warren, *in* Allan et al., 1932) as described and illustrated by Crickmay (1953, p. 3, 4, Pl. 2, figs. 9–13). The type specimens of *E. jasperensis* are from the same bed and locality as *Allanella minutilla* Crickmay (1953). *Mucrospirifer williamsi* n. sp. is distinguished from *E. jasperensis* by its smaller size, its fewer costae on the flanks (5–8 versus about

12), and by its more rounded and less extended pedicle umbo and beak.

The narrower variant (form A) of *Mucrospirifer williamsi* n. sp. also bears a close resemblance in size and shape to *Eleutherokomma impennis* Crickmay (1953, p. 3, Pl. 2, figs. 1-8) from the Firebag and Peace Point members of the Waterways Formation of northeastern Alberta (see Norris and Uyeno, 1981, 1983). *Mucrospirifer williamsi* n. sp. is separated from *E. impennis* by its much lower and more incurved pedicle and brachial interareas, its generally less indented lateral margins immediately anterior of the cardinal extremities, a less inflated brachial valve, and smaller size at maturity.

Occurrence. Locality Ab-"11" (=GSC loc. C-136485); green, "clay-shale" bed, 1.3 m thick, uppermost Williams Island Formation; east bank of Abitibi River, immediately south of Williams Island.

Figured and/or measured specimens. Paratype ROM 47344, a wide, adult shell (form B); holotype ROM 47345, a narrow, adult shell (form A); paratype ROM 47346, an incomplete pedicle valve of a young, narrow individual (form A); paratype ROM 47347, an incomplete pedicle valve of a wide, adult individual (form B); paratype ROM 47348, brachial valve of a young individual (form B); paratype ROM 47349, a wide, young adult individual (form B) (serially sectioned); and paratype ROM 47350, a relatively narrow, young adult individual (form A) (serially sectioned).

II. CONODONTS — T.T. UYENO

The familial classification used in Supplement 2 of Part W of the Treatise on Invertebrate Paleontology (Robison, 1981) is followed herein. The locational notation used in the cited Treatise is also followed, with the exception of the icriodontid apparatus; for it, the scheme introduced by Klapper and Philip (1971, 1972), and subsequently expanded by Johnson and Klapper (1981), is used.

Order CONODONTOPHORIDA Eichenberg, 1930

Family ICRIODONTIDAE Müller and Müller, 1957

Genus *Icriodus* Branson and Mehl, 1938.

Type species. Icriodus expansus Branson and Mehl, 1938.

Icriodus symmetricus Branson and Mehl

Plate 16, figures 7-16

1934 *Icriodus symmetricus* n. sp., Branson and Mehl, p. 226, Pl. 13, figs. 1-3.

1975 *Icriodus symmetricus* Branson and Mehl. Klapper *in* Ziegler, ed., p. 151-153, *Icriodus*-Pl. 3, figs. 7, 8.

1985 *Icriodus symmetricus* Branson and Mehl. Klapper and Lane, p. 921, Fig. 11.1.

Remarks. In collections from GSC locality 100799, two types of simple cones are associated with the I element of *Icriodus symmetricus*. They may be the S_2 elements, and are similar to those designated as S_{2a} and S_{2b} by Uyeno (1978).

In most specimens assigned to this species, the I element has three denticles in the middle row projecting posteriorly of the lateral rows, and the middle row denticles in the posterior part of the spindle are higher than the lateral denticles; the middle row denticles are further connected by a fine longitudinal ridge (see Klapper *in* Ziegler, 1975, p. 151-153). One specimen from GSC locality C-136485 exhibits a solid ridge in the middle row posterior of the lateral rows.

Material. 61 I, 3 S_{2a}, and 2 S_{2b} elements (Fig. 8).

Family POLYGNATHIDAE Bassler, 1925

Genus *Mehlina* Youngquist, 1945

Type species. Mehlina irregularis Youngquist, 1945 (= junior synonym of *Mehlina gradata* Youngquist, 1945).

Mehlina? sp. cf. *M. gradata* Youngquist

Plate 16, figures 17-21, 23, 24

cf. 1945 *Mehlina gradatus* n. sp., Youngquist, p. 363, Pl. 56, fig. 3.

cf. 1985 *Mehlina gradata* Youngquist. Klapper and Lane, p. 921, Fig. 12.1 (synonymy).

Remarks. Several specimens that are suggestive of *Mehlina gradata* are present in the Long Rapids collections. They differ from that species in displaying a wide range of basal cavity size, none of which is so small that it can be called a pit. The inverted portion of the basal cavity shows a similarly wide range of variation, which in some specimens is restricted to posterior of the cavity, and in others extends throughout the length of the blade (compare Pl. 16, figs. 18, 21, and 24). Because the description above does not match the concept of the genus (see Youngquist, 1945; Klapper *in* Robison, 1981), the specimens are only questionably referred to *Mehlina*.

The number of denticles is highly variable, ranging from 12 to 19.

Material. 186 Pa elements (Fig. 8).

Mehlina sp.

Plate 16, figure 25

1985 *Mehlina* sp., Klapper and Lane, p. 921, Fig. 12.2.

Remarks. Fourteen specimens fit the generic criteria of having a pit and, posteriorly, an inverted basal cavity. The acicular and reclined denticulation matches that of the specimen from the Kakisa Formation, illustrated by Klapper and Lane (1985).

Material. 14 Pa elements (Fig. 8).

Genus *Ozarkodina* Branson and Mehl, 1933a

Type species. Ozarkodina typica Branson and Mehl (= junior synonym of *Hindeodella confluens* Branson and Mehl, 1933a).

Ozarkodina postera Klapper and Lane

Plate 17, figures 1–4

1985 *Ozarkodina postera* n. sp., Klapper and Lane, p. 922, 923, Figs. 12.3–12.9, 13.1–13.15.

1989 *Ozarkodina postera* Klapper and Lane. Klapper and Lane, p. 474.

Remarks. The apparatus of *Ozarkodina postera* was reconstructed by Klapper and Lane (1985). The Pb element present in the Long Rapids collections is similar in its denticulation pattern and overall outline to its counterpart in the Middle Devonian apparatus of *Ozarkodina brevis* (Bischoff and Ziegler) (Uyeno *in* Norris et al., 1982, Pl. 32, figs. 31, 32; Nicoll, 1985, Figs. 7A, 7B). It is also similar, as previously noted by Klapper and Lane (1985), to its counterpart in the apparatus of *Ozarkodina raaschi* Klapper and Barrick.

Material. 5 Pa and 3 Pb elements (Fig. 8).

Genus *Ancyrodella* Ulrich and Bassler, 1926

Type species. Ancyrodella nodosa Ulrich and Bassler, 1926.

Ancyrodella alata Glenister and Klapper

Plate 15, figures 11–14

1966 *Ancyrodella rotundiloba alata* n. subsp., Glenister and Klapper, p. 799, 800, Pl. 85, figs. 1–8; Pl. 86, figs. 1–4.

1985 *Ancyrodella alata* Glenister and Klapper. Klapper, p. 27, 28, Pl. 4, figs. 1–8; Pl. 5, figs. 1–16; Pl. 6, figs. 1–12; Pl. 7, figs. 1–11; Pl. 8, fig. 8; Textfigs. 3K, L, O–R (synonymy).

Remarks. Only the "early" form of *Ancyrodella alata* (of Klapper, 1985) is present in the Ontario collections.

Material. 2 Pa elements (Fig. 8).

Ancyrodella nodosa Ulrich and Bassler

Plate 16, figures 1–6

1926 *Ancyrodella nodosa* n. sp., Ulrich and Bassler, p. 48, Pl. 1, figs. 10–13.

1985 *Ancyrodella nodosa* Ulrich and Bassler. Klapper and Lane, p. 925, 926, Figs. 14.6, 14.7, 14.10, 14.11 (synonymy).

1985 *Ancyrodella nodosa* Ulrich and Bassler. Olivieri, p. 282, Pl. 3, figs. 3, 4.

1987 *Ancyrodella nodosa* Ulrich and Bassler. Fuchs, Pl. 3, figs. 5, 7, 10.

Material. 53 Pa elements (Fig. 8).

Ancyrodella rotundiloba (Bryant)

Plate 15, figures 5(?), 6(?), 7, 8, 15–18(?), 19, 20, 21(?), 22(?)

1921 *Polygnathus rotundilobus* n. sp., Bryant, p. 26, 27, Pl. 12, figs. 1–6; Textfig. 7.

1985 *Ancyrodella rotundiloba* (Bryant). Klapper, p. 24, 26, 27, Pl. 1, figs. 1–20; Pl. 2, figs. 1–12; Pl. 3, figs. 1–12; Pl. 4, figs. 9–12; Pl. 8; figs. 9, 10; Pl. 11, figs. 3, 4; Textfigs. 3A–J, M, N (synonymy).

Remarks. Both the "early" and "late" forms of *Ancyrodella rotundiloba*, as defined by Klapper (1985), are present at GSC locality C-136486.

The specimen illustrated in Plate 15, figures 7, 8 is close to the Pa element of *Ancyrodella pristina* Chalimbadscha and Tschernyscheva, a species now considered to be a junior synonym of *A. binodosa* Uyeno (see Ziegler *in* Ziegler, 1973, p. 35). Its two principal nodes, located on the anterior part of the platform, however, are not as prominent as those in *A. pristina*, and are more comparable to the principal anterior nodes of *A. rotundiloba* subsp. A of Uyeno (1974).

Material. Early form: 1 Pa element; 3 Pa elements questionably assigned. Late form: 1 Pa element; 2 Pa elements questionably assigned (Fig. 8).

Genus *Ancyrognathus* Branson and Mehl, 1934

Type species. Ancyrognathus symmetricus Branson and Mehl, 1934.

Ancyrognathus euglypheus Stauffer sensu Coen (1973)

Plate 17, figures 18, 19, 20(?)

1973 *Ancyrognathus triangularis* Youngquist *euglypheus* Stauffer. Coen, p. 252, Pl. 1, figs. 1, 2.

1989a *Ancyrognathus euglypheus* of Coen. Klapper, p. 458, Pl. 4, figs. 9, 13.

Remarks. A single specimen of this species was recovered from GSC locality C-136491. The species is kept in this form of nomenclature as taxonomic revision is currently being undertaken by Klapper (1989, p. 457).

Within his new species of *Ancyrognathus*, *A. tsiensi*, Mouravieff (1982, p. 105) included *A. euglypheus* sensu Coen (1973). One of the principal differences between them appears to be in the lateral profile of the high denticles in the anterior part of the carina; in *A. tsiensi*, the posteriormost denticle of the series is the highest, with an abrupt lowering to the remainder of the carina, whereas in *A. euglypheus* sensu Coen (1973), the profile is rounded so that the highest denticle is in the middle.

Material. 3 Pa elements, 1 Pa element questionably assigned (Fig. 8).

Ancyrognathus triangularis Youngquist

Plate 17, figures 5(?), 6(?), 7, 8(?), 9(?)

1945 *Ancyrognathus triangularis* n. sp., Youngquist, p. 356, 357, Pl. 54, fig. 7.

1980 *Ancyrognathus triangularis* Youngquist. Schönlaub, Pl. 9, fig 26.

1980 *Ancyrognathus triangularis* Youngquist. Perri and Spalletta, p. 296, 298, Pl. 3, figs. 2, 3.

1981 *Ancyrognathus triangularis* Youngquist. Ziegler *in* Ziegler, ed., p. 23–25, *Ancyro-* Pl. 5, figs. 1–3, 5, 9 (10(?) = juvenile) (synonymy).

1982 *Ancyrognathus triangularis* Youngquist. Mouravieff, Pl. 5, figs. 10, 12–15; Pl. 6, figs. 1–3, 6.

1982 *Ancyrognathus triangularis* Youngquist. Morzadec and Weyant, p. 30, Pl. 3, figs. 5, 6.

1983 *Ancyrognathus triangularis* Youngquist. Wang and Ziegler, Pl. 1, figs. 9, 10, 12.

1985 *Ancyrognathus triangularis* Youngquist. Austin et al., p. 150, Pl. 4.6, figs. 4–6.

1985 *Ancyrognathus triangularis* Youngquist. Olivieri, p. 284, 286, Pl. 3, figs. 1, 2.

1987 *Ancyrognathus triangularis* Youngquist. Fuchs, Pl. 4, figs. 1–7; Pl. 21, fig. 1.

1987 *Ancyrognathus triangularis* Youngquist. Garcia-Lopez, p. 66, 67, Pl. 3, figs. 14, 15.

1989a *Ancyrognathus triangularis* Youngquist. Klapper, p. 458, Pl. 4, figs. 6, 7.

Remarks. Only a single specimen from GSC locality C-136490 can be identified with the Pa element of *Ancyrognathus triangularis*. Small specimens were recovered from GSC localities 100799, C-136490, and C-136491, which may represent early growth stages of this species and are herein questionably identified with this species. These small specimens exhibit an angle between the main and secondary carinae of 90 degrees or more, and the secondary lobe is directed laterally. The secondary lobe of the single small form that is tentatively assigned to *A. euglypheus* sensu Coen (1973), on the other hand, is more posteriorly oriented.

Material. 1 Pa element, 20 Pa elements questionably assigned (Fig. 8).

Genus *Mesotaxis* Klapper and Philip, 1972

Type species. Polygnathus asymmetricus Bischoff and Ziegler.

Mesotaxis ex gr. *M. asymmetrica* (Bischoff and Ziegler)

Plate 16, figure 22

Ex gr. 1957 *Polygnathus dubia asymmetrica* n. subsp., Bischoff and Ziegler, p. 88, 89, Pl. 16, figs. 18, 20–22; Pl. 21, fig. 3.

Remarks. A singe, large, fragmented platform element from GSC locality C-136486 has features of the *Mesotaxis asymmetrica* group (see Ziegler and Klapper, 1982, p. 471). The basal cavity, critical for specific identification, is obscured by a large basal plate that covers almost the entire lower surface of the platform.

Material. 4 Pa elements (Fig. 8).

Genus *Palmatolepis* Ulrich and Bassler, 1926

Type species. Palmatolepis perlobata Ulrich and Bassler, 1926.

Palmatolepis domanicensis Ovnatanova

Plate 12, figure 22

1976 *Palmatolepis domanicensis* n. sp., Ovnatanova, p. 109, Pl. 9, figs. 1, 2.

1989a *Palmatolepis domanicensis* Ovnatanova Klapper, p. 458, Pl. 1, figs. 1, 2.

1989 *Palmatolepis domanicensis* Ovnatanova. Klapper and Lane, Pl. 2, figs. 21–23.

Remarks. In comparison with *Palmatolepis foliacea* Youngquist, *P. domanicensis* has a broader platform with a better developed incipient lateral lobe.

Material. 3 Pa elements (Fig. 8).

Palmatolepis foliacea Youngquist

Plate 13, figure 13

1945 *Palmatolepis foliaceus* (sic) n. sp., Youngquist, p. 364, 365, Pl. 56, figs. 11, 12.

1957 *Palmatolepis* (*Manticolepis*) *foliacea* (Youngquist). Müller and Müller, p. 1102, Pl. 140, figs. 6, 7, 9.

1989a *Palmatolepis foliacea* Youngquist. Klapper, p. 458.

1989 *Palmatolepis foliacea* Youngquist. Klapper and Lane, Pl. 2, figs. 18–20.

Remarks. Palmatolepis foliacea is present in the highest sample, GSC locality C-136493. In the same collection are Pa elements with an outline similar to *P. domanicensis* but which, like *P. foliacea*, possess a less well developed incipient lateral lobe; they are herein referred to as *Palmatolepis* sp. cf. *P. foliacea* (Pl. 13, figs. 11, 12).

Material. 11 Pa elements; 39 Pa elements assigned to *P.* sp. cf. *P. foliacea* (Fig. 8).

Palmatolepis kireevae Ovnatanova

Plate 12, figures 7–19

1976 *Palmatolepis kireevae* n. sp., Ovnatanova, p. 111, Pl. 9, fig. 5.

1986 *Palmatolepis hassi* Müller and Müller. Klapper and Foster, Pl. 1, figs. 9–12; Pl. 2, figs. 9–14.

1989a *Palmatolepis kireevae* Ovnatanova. Klapper, p. 458, Pl. 2, figs. 2, 6.

Remarks. Present in the Long Rapids Formation collections are two slightly differing morphotypes of Pa elements. One matches the description and illustration provided by Ovnatanova (1976), Klapper and Foster (1986), and Klapper (1989a), and is herein designated as *Palmatolepis kireevae*. The other has a broader platform and a lateral lobe with a tendency toward a rounded, rather than a pointed, distal end, and is assigned to *P.* sp. cf. *P. kireevae* (Pl. 12, figs. 20, 21). Two slightly differing M elements are present as well, although both are similar to that illustrated by Klapper and Foster (1986). One is of sturdier construction than the other, with thicker lateral processes and denticles (Pl. 12, figs. 12, 13, 15, 18, 19). The M element of more delicate construction was found only at GSC locality C-136493. The Pb element is similar to those previously assigned to *P. kireevae* by Klapper and Foster (1986), and in collections where both Pa morphotypes occur, the assignment of the Pb element to one or the other morphotype is arbitrary.

Material. 108 Pa elements; 17 Pa elements of *P.* sp. cf. *P. kireevae*; 49 Pb elements and 5 M elements (Fig. 8).

Palmatolepis sp. aff. *P. rhenana* Bischoff

Plate 13, figures 9, 14, 15

1989a *Palmatolepis* aff. *P. rhenana* Bischoff. Klapper, p. 458.

1989 *Palmatolepis* aff. *P. rhenana* Bischoff. Klapper and Lane, Pl. 1, figs. 10–13.

Material. 8 Pa elements (Fig. 8).

Palmatolepis unicornis Miller and Youngquist

Plate 12, figures 23, 24

1947 *Palmatolepis unicornis* n. sp., Miller and Youngquist, p. 514, Pl. 75, fig. 15.

1985 *Palmatolepis unicornis* Miller and Youngquist. Klapper and Lane, p. 930, Fig. 15.15 (synonymy).

Material. 5 Pa elements (Fig. 8).

Palmatolepis winchelli (Stauffer)

Plate 13, figures 1–8, 10

1938 *Bryantodus winchelli* n. sp., Stauffer, p. 423, Pl. 48, fig. 33.

1947 *Palmatolepis subrecta* n. sp., Miller and Youngquist, p. 513, 514, Pl. 75, figs. 7–11.

1982 *Palmatolepis subrecta* Miller and Youngquist. Mouravieff, Pl. 7, fig. 14.

1986 *Palmatolepis subrecta* Miller and Youngquist. Klapper and Foster, Pl. 1, figs. 5–8; Pl. 2, fig. 7.

1989a *Palmatolepis winchelli* (Stauffer). Klapper, p. 458, Pl. 2, fig. 5.

1989 *Palmatolepis winchelli* (Stauffer). Klapper and Lane, Pl. 1, figs. 5, 8.

Material. 42 Pa, 5 Pb, and 2 M elements (Fig. 8).

Palmatolepis sp. A

Plate 12, figures 5, 6

Remarks. The Pa element of *Palmatolepis* sp. A has a general outline and surface ornamentation similar to that of *P. kireevae* Ovnatanova, but differs principally in its short lateral lobe and more bluntly pointed posterior end. The Pb element is gently arched and its posterior part inwardly bent with only incipiently developed lateral platforms. There are synprioniodinan elements present in the same collection from GSC locality C-136488, but whether they belong to this species cannot be determined at this time.

Material. 3 Pa and 1 Pb elements (Fig. 8).

Palmatolepis sp. indet.

Plate 12, figures 1–4

? 1981 *Palmatolepis transitans* Müller *vel P. disparilis* Ziegler and Klapper. Bultynck and Hollard, p. 41, Pl. 8, fig. 19.

Remarks. A palmatolepid platform element, represented by two specimens, one of which is fragmentary and the other small (?juvenile), was recovered from GSC locality C-136485. The platform outline, upper surface ornamentation, and the blade-carina length and curvature are somewhat similar to those of *Palmatolepis transitans* Müller and *P. disparilis* Ziegler and Klapper. The exact nature of the pit and cavity is unknown as the lower surface is partly covered with a basal plate. Bultynck and Hollard (1981) recorded a somewhat similar form from southern Morocco.

Material. 2 Pa elements (Fig. 8).

Genus *Polygnathus* Hinde, 1879

Type species. Polygnathus dubius Hinde, 1879.

Polygnathus sp. aff. *P. angustidiscus* Youngquist

Plate 14, figures 19–21

Aff. 1945	*Polygnathus angustidiscus* n. sp., Youngquist, p. 365, Pl. 54, fig. 2 (= lectotype selected by Müller and Müller, 1957, p. 1084).
Aff. 1985	*Polygnathus* aff. *P. angustidiscus* Youngquist. Klapper and Lane, p. 932, Figs. 16.2–16.6.

Remarks. Two Pa elements exhibit a relatively short platform with carina extending posteriorly beyond the platform edge, and a short, high, free blade. These features are also present in *Polygnathus angustidiscus*, but the platform is more fully developed in the present specimens. Similar forms were illustrated by Klapper and Lane (1985) from the Hay River Formation near Great Slave Lake, District of Mackenzie.

Material. 3 Pa elements (Fig. 8).

Polygnathus aspelundi Savage and Funai

Plate 15, figure 4

1980	*Polygnathus aspelundi* n. sp., Savage and Funai, p. 812, Pl. 2, figs. 18–33.
1985	*Polygnathus aspelundi* Savage and Funai. Klapper and Lane, p. 934, Fig. 16.1.

Remarks. The Long Rapids polygnathiform element (GSC loc. C-136493) differs slightly from those reported from Alaska by Savage and Funai (1980), in that the platform outline of the dextral element more closely matches the description of the sinistral element.

Two polygnathiform elements from GSC locality C-136491 are superficially suggestive of *Polygnathus aspelundi* (illustrated in Pl. 15, figs. 1–3). They differ in having a wider platform and a longer free blade that is almost the same length as the platform. Similarities include a carina that extends posteriorly beyond the platform, and a slight flare on the outer posterior platform margin.

Material. 1 Pa element; 6 Pa elements questionably assigned (Fig. 8).

Polygnathus brevis Miller and Youngquist sensu Szulczewski (1972)

Plate 15, figures 9, 10

1972	*Polygnathus brevis* Miller and Youngquist. Szulczewski, p. 450, 451, Pl. 1, figs. 1–7, Pl. 2, figs. 1–4.

Remarks. The Pa element is almost identical to those illustrated and described by Szulczewski (1972). Most of the Polish specimens display continuous ridges in the posterior third of the platform, although one (Pl. 2, fig. 1), like the present material, has a series of short, broken ridges. This feature is similar to that displayed by one of the topotype specimens of *Polygnathus brevis* illustrated by Klapper and Lane (1985, Fig. 17.6). Klapper and Lane (op. cit., p. 944) noted that Szulczewski's (1972) specimens are closer to *P. samueli* Klapper and Lane than to *P. brevis* in their platform outline and configuration of the adcarinal troughs. In the Long Rapids specimen as well as in some of the Polish specimens, the adcarinal trough is bordered on one side by a series of nodes and on the other by a series of transverse ridges. The present species differs from *P. samueli* in details of platform ornamentation and the slight tendency to develop a conspicuous sinus in the outer posterior margin, as noted by Klapper and Lane (1985).

The Polish collections are from the Holy Cross Mountains, and occur in the Lower and Upper *gigas* zones. The Ontario specimen was found in the Lower *gigas* Zone.

Material. 1 Pa element (Fig. 8).

Polygnathus decorosus Stauffer

Plate 14, figures 9–17

1938 *Polygnathus decorosus* n. sp., Stauffer, p. 438, Pl. 53, figs. 5, 6, 10, 15, 16 (only).

1970 *Polygnathus decorosus* Stauffer. Klapper, Philip and Jackson, p. 652–654, Pl. 3, figs. 1–6.

1973 *Polygnathus decorosus* Stauffer. Klapper *in* Ziegler, p. 351, 352, *Polygnathus*- Pl. 1, fig. 5 (synonymy).

1981 *Polygnathus decorosus* Stauffer. Duffield and Warshauer, Pl. 1, fig. 13.

1983 *Polygnathus decorosus* Stauffer. Van den Boogaard, p. 6–8, Pl. 4, figs. 1–8, 9(?), 10.

1983 *Polygnathus decorosus* Stauffer. Wang and Ziegler, Pl. 6, fig. 9.

1985 *Polygnathus decorosus* Stauffer. Klapper and Lane, p. 935, Fig. 18.7.

Remarks. The specimen referred to this species by Huddle (1981, Pl. 17, figs. 13–15) has an extremely long free blade, about two thirds of the unit length. The Pa element of this species characteristically has a free blade about half of the unit length. The specimen also differs in its coarse denticulation pattern on the platform.

The "avisgnathiform" element that van den Boogard (1983, Pl. 4, fig. 9) suggested as a possible Sa candidate was not found in any of the present collections.

Polygnathid specimens (illustrated in Pl. 14, figs. 1–8) herein identified as *Polygnathus* sp. cf. *P. decorosus*, from GSC locality 100799, have some features similar to those of *P. decorosus* and *P. dubius*. The subsymmetrical platform is relatively wide with a trace of rostral development in some specimens (Pl. 14, fig. 1). The upper surface of the platform displays coarse, widely spaced transverse ridges, with random scattering of nodes on the extreme posterior tip. The free blade ranges from about a third to over half of the unit length. In lateral view, the denticles may be wide and few in number and highest at midlength, or the denticles may be narrow and numerous, with the blade gradually becoming higher anteriorly. Huddle (1970, p. 1037) makes no mention of this feature in *P. dubius*, although both types are illustrated (ibid., Pl. 138, figs. 1, 2, 8, 16, 23). Klapper and Lane (1985, Fig. 18.7) illustrated a specimen from the Hay River Formation of southwestern District of Mackenzie that is somewhat similar to those from the Long Rapids Formation.

The specimen illustrated in Plate 14, figure 9 has a relatively wide platform and approaches *Polygnathus* sp. cf. *P. decorosus* cited above.

Material. 246 Pa elements; 62 Pa elements of *P.* sp. cf. *P. decorosus* (Fig. 8).

Polygnathus dengleri Bischoff and Ziegler

Plate 13, figures 16–18

1975 *Polygnathus dengleri* n. sp., Bischoff and Ziegler, p. 87, 88, Pl. 15, figs. 14, 15, 17–24; Pl. 16, figs. 1–4.

1980 *Polygnathus* aff. *P. dengleri* Bischoff and Ziegler. Savage and Funai, p. 811, Pl. 1, figs. 20–27.

1980 *Polygnathus dengleri* Bischoff and Ziegler. Klapper *in* Johnson et al., p. 102, Pl. 4, figs. 24–28, 30.

1980 *Polygnathus dengleri* Bischoff and Ziegler. Perri and Spalletta, p. 305, Pl. 7, figs. 1, 2.

1981 *Polygnathus dengleri* Bischoff and Ziegler. Huddle, p. B29, Pl. 6, Figs. 15–23.

1981 *Polygnathus dengleri* Bischoff and Ziegler. Bultynck and Hollard, p. 42, Pl. 8, figs. 2, 3.

1981 *Polygnathus dengleri* Bischoff and Ziegler. Bultynck and Jacobs, p. 19, Pl. 7, figs. 1–3, 6–9.

1985 *Polygnathus dengleri* Bischoff and Ziegler. Orchard *in* Austin et al., p. 146, Pl. 4.5, figs. 6, 8.

1986 *Polygnathus dengleri* Bischoff and Ziegler. Ziegler and Wang, Pl. 2, fig. 8; Pl. 3, fig. 15.

1987 *Polygnathus dengleri* Bischoff and Ziegler. Fuchs, Pl. 10, figs. 6–8; Pl. 11, figs. 2, 3.

Remarks. By comparison with the Nevada Antelope Range sequence (Klapper *in* Johnson et al., 1980), the present specimens appear to be closer to that morphotype occurring in the *disparilis* Zone (formerly Lower *dengleri* Subzone; see Ziegler and Klapper, 1982, p. 475, 476), and designated as morphotype beta by Bultynck and Jacobs (1981, p. 19). It is characterized by relatively coarse and irregular transverse ridges and nodes on the platform of the Pa element.

Range. In Montagne Noire, France, *P. dengleri* ranges from within the *disparilis* Zone (its base informally subdivides that zone) to within the Lower *asymmetrica* Zone or Zone 3 (Klapper, 1985, 1989a).

Material. 13 Pa elements (Fig. 8).

Polygnathus dubius Hinde

Plate 13, figures 24-30

1879 *Polygnathus dubius* n. sp., Hinde, p. 362-364, Pl. 16, fig. 17.

1970 *Polygnathus dubius* Hinde. Huddle, p. 1037, Pl. 138, figs. 1-17 (includes synonymy).

1973 *Polygnathus dubius* Hinde. Klapper *in* Ziegler, ed., p. 353, 354, *Polygnathus*- Pl. 1, figs. P, 01, N, A1-3, 1.

1979 *Polygnathus dubius* Hinde. Uyeno, p. 244, Pl. 2, fig. 11.

1979 *Polygnathus dubius* Hinde. Baliński, p. 79, 80, Pl. 23, figs. 5, 6.

1981 *Polygnathus dubius dubius* Hinde. Huddle, p. B29, Pl. 18, figs. 13-18.

1982 *Polygnathus dubius* Hinde. Bultynck, p. 39, Pl. 3, figs. 9-14.

1983 *Polygnathus dubius* Hinde. Raven, p. 307, Pl. 3, fig. 9.

1985 *Polygnathus dubius* Hinde. Racki, Pl. 6, figs. 5, 9.

1986 *Polygnathus dubius* Hinde. Ziegler and Wang, Pl. 2, fig. 10.

1987 *Polygnathus dubius* Hinde. Garcia-Lopez, p. 88, 89, Pl. 14, figs. 4-16.

Remarks. According to Huddle (1970), the Pa element of *Polygnathus dubius* can be rather variable. Apart from having the common feature of a rostrum, the platform outline can be narrow and lanceolate, or be widest in its middle third and sharply tapering anteriorly and posteriorly. The free blade ranges from about a third to one half of the unit length, with its highest part near the middle or closer to the anterior edge. The upper surface of the platform may be covered with coarse nodes, or have subdued nodes near the lateral margins. The range of variation cited above is found in the present collections.

Material. 43 Pa elements (Fig. 8).

Polygnathus evidens Klapper and Lane

Plate 14, figures 18, 22-29

1985 *Polygnathus evidens* n. sp., Klapper and Lane, p. 935, 936, Figs. 20.1-20.8.

Remarks. The inner platform margin of the Pa element is nearly straight to gently incurved in most specimens. The outer platform margin may have a gentle sinus in its anterior half. The free blade constitutes between a quarter and a third of the unit length.

Material. 256 Pa elements (Fig. 8).

Polygnathus pennatus Hinde

Plate 13, figures 19-23

1879 *Polygnathus pennatus* n. sp., Hinde, p. 366, Pl. 17, fig. 18.

1973 *Polygnathus pennatus* Hinde. Klapper *in* Ziegler, ed., p. 373, *Polygnathus*- Pl. 1, fig. 7 (synonymy).

1980 *Polygnathus pennatus* Hinde. Klapper *in* Klapper and Johnson, p. 454 (further synonymy).

1981 *Polygnathus pennatus* Hinde. Huddle, p. B31, Pl. 12, figs. 4-6.

1981 *Polygnathus pennatus* Hinde. Bultynck and Hollard, p. 45, Pl. 8, fig. 21.

1985 *Polygnathus pennatus* Hinde. Orchard *in* Austin et al., p. 148, Pl. 4.5, fig. 14.

1986 *Polygnathus pennatus* Hinde. Bardashev and Ziegler, Pl. 2, fig. 9.

Material. 32 Pa elements (Fig. 8).

Family HIBBARDELLIDAE Müller, 1956

Genus *Oulodus* Branson and Mehl, 1933b

Type species. Oulodus mediocris Branson and Mehl, 1933b [= junior synonym of *Oulodus serratus* (Stauffer, 1930)].

Oulodus? sp.

Plate 17, figures 10–12, 16, 17, 21

Remarks. A collection of ten specimens from GSC locality 100799 is questionably referred to the genus *Oulodus*. The absence of the Pa element makes generic assignment tentative. The Sa element has only a stubby, adenticulate posterior process, and in this respect the apparatus is closer to *Oulodus* than to *Hibbardella* (see Sweet, 1988, p. 81).

Material. 2 Pb, 1M, 1 Sa, 1 Sb, and 5 Sc elements (Fig. 8).

Family UNKNOWN

Genus *Elsonella* Youngquist, 1945

Type species. Elsonella prima Youngquist, 1945.

Elsonella secunda Youngquist

Plate 17, figures 13–15

1945 *Elsonella secunda* n. sp., Youngquist, p. 359, Pl. 56, fig. 4.

Remarks. A specimen was recovered from GSC locality C-136491 that is closely similar to a bipennate ramiform (Sc) element, described by Youngquist (1945), from the Independence Shale of Iowa.

The specimen exhibits a polygonal pattern (of Conway Morris and Harper, 1988) or "oral fine nets" (of Ji, 1988), a feature that appears to be more prevalent on the upper surfaces of those parts of the element that are laterally projected. Near and at the bases of the denticles, the polygonal pattern is distorted and elongated, and becomes increasingly so on the lateral surfaces of the denticles. The upper parts of the lateral surfaces of the denticles are finely striated. This feature is also present in the Pa and Pb elements of certain *Palmatolepis* apparatuses, and the Pa element of *Ancyrognathus triangularis* Youngquist, and this suggests that *Elsonella secunda* may be an Sc component of a similar apparatus. Other forms with similar textural and denticulation pattern were also recovered from the same locality (GSC loc. C-136491). They may fill the M? and Pb positions of the same apparatus.

Elsonella prima Youngquist (1945, p. 358, 359, Pl. 56, fig. 5) is probably the Sa component of the same apparatus.

Material. 4 Sc, 5 Pb, and 3 M? elements (Fig. 8).

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APPENDIX

LOCALITY REGISTER

Localities are listed in ascending stratigraphic sequence.

Locality Ab-"11"

Locality Ab-"11" is equivalent to GSC locality C-136485. It is a unit, 1.3 m exposed, of pale green, clay-mudstone containing three thin, concretionary carbonate beds, and with numerous brachiopods at the base. This unit, assigned to the uppermost Williams Island Formation, forms the base of a section with about 36.2 m exposed (Fig. 4) on the east bank of the Abitibi River immediately south of the south end of Williams Island at 50°23′50″N, 81°33′51.6″W (NTS 42 I), Moose River Basin, of the Hudson Bay Lowlands, northern Ontario (Figs. 1, 3). Megafossils were collected by P.G. Telford, then of the Ontario Geological Survey, September 9, 1984, and include the following brachiopods decribed in this report by A.W. Norris and P. Sartenaer:

Schizophoria sp. cf. *S. athabaskensis* Warren
Strophodonta (*Strophodonta*) *abitibiensis* Norris n. sp.
Nervostrophia ralla Norris n. sp.
Eostrophalosia parksi Norris n. sp.
Ladogioides pusilla Sartenaer n. sp.
Leiorhynchus quadracostatus alces Sartenaer n. subsp.
Atryparia rubra Cooper and Dutro
Desquamatia (*Independatrypa*) *exila* Norris n. sp.
Desquamatia (*Independatrypa*) sp. A
Desquamatia (*Independatrypa*) sp. B
Spinatrypa (*Spinatrypa*) sp. A
Spinatrypa (*Spinatrypa*) *tribulosa* Norris n. sp.
Emanuella martisoni Norris n. sp.
Ladjia? *plicata* Norris n. sp.
Cyrtina sp. aff. *C. triquetra* (Hall)
Tecnocyrtina bicostata Norris n. sp.
Mucrospirifer williamsi Norris n. sp.

Other megafossils present in the sample, which were not studied, include:

Tabulophyllum sp. (to be studied by A.E.H. Pedder)
echinoderm ossicle with single axial canal
Pleurotomaria sp.
Phacops sp.

Conodonts identified by T.T. Uyeno are listed in Figure 7.

Locality JM-1

Locality JM-1 consists of argillaceous limestone beds, assigned to the uppermost Williams Island Formation, outcropping just above river level on the west bank of the Abitibi River about a quarter of a mile (0.4 km) north of the north end of Williams Island (Sanford and Norris, 1975, p. 70), at approximately 50°24′32.14″N, 81°34′23.33″W (NTS 42 I), in the Moose River Basin of the Hudson Bay Lowlands, northern Ontario (Fig. 3). From this locality, John Monteith of the Royal Ontario Museum in 1952 collected over 40 specimens of a leiorhynchid described in this report as *Leiorhynchus quadracostatus alces* Sartenaer n. subsp.

Locality Ab-3

Locality Ab-3 is equivalent to GSC locality C-136486. The sample is from a carbonate concretionary layer within a unit of pale green, clay-mudstone assigned to the uppermost Williams Island Formation, 0.3 m thick, about 1.0–1.3 m above the base of the section. The location is the same as for locality Ab-"11" (= GSC loc. C-136485).

Conodonts identified by T.T. Uyeno are listed in Figure 7.

Locality Ab-4

Locality Ab-4 is equivalent to GSC locality C-136487. The sample is from a carbonate concretionary layer within a unit of pale green, clay-mudstone assigned to the uppermost Williams Island Formation, 1.3 m thick, about 0.7 m above the base of the section. The location is the same as for locality Ab-"11" (= GSC loc. C-136485).

Conodonts identified by T.T. Uyeno are listed in Figure 7.

Locality Ab-5

Locality Ab-5 is equivalent to GSC locality C-136488. The sample is from a greyish green micritic limestone bed, 0.33 m thick, within a dark grey shale, 7.4 to 7.7 m above the base of the section, Long

Rapids Formation. The location is the same as for locality Ab-"11" (= GSC loc. C-136485).

Conodonts identified by T.T. Uyeno are listed in Figure 7.

Locality Ab-6

The sample from locality Ab-6 (= Field No. 84SA3; GSC loc. 100799) is from a greyish green, micritic limestone bed, 0.05 m thick, within dark grey to black shale, 8.2 m above the base of the section, Long Rapids Formation. The location is the same as for locality Ab-"11" (= GSC loc. C-136485). This thin limestone bed contains numerous goniatites and sparse fragmentary brachiopods, collected by B.V. Sanford, Geological Survey of Canada, and P.G. Telford, Ontario Geological Survey, September 12, 1984.

Megafossils include the following:

Manticoceras sp. cf. *M. sinuosum* (Hall) (identified by W.W. Nassichuk)
Lingula sp. (identified and described by A.W. Norris)
Lingulipora sp. (identified and described by A.W. Norris)
Calvinariid sp. (identified and described by A.W. Norris)
undet. spirally coiled gastropod
large attached echinoderm columnals

Conodonts identified by T.T. Uyeno are listed in Figure 7.

Locality Ab-7

Locality Ab-7 is equivalent to GSC locality C-136489. The sample is from a greyish green limestone bed, 0.1 m thick, overlain and underlain by dark grey shale, 8.3 to 8.4 m above the base of the section, Long Rapids Formation. The location is the same as for locality Ab-"11" (= GSC loc. C-136485).

Conodonts identified by T.T. Uyeno are listed in Figure 7.

Locality Ab-8

Locality Ab-8 is equivalent to GSC locality C-136490. The sample is from a very thin, light green, micritic limestone bed, 0.1 m thick, overlain and underlain by dark shale, 8.9 to 9.0 m above the base of the section, Long Rapids Formation. The location is the same as for locality Ab-"11" (= GSC loc. C-136485).

Conodonts identified by T.T. Uyeno are listed in Figure 7.

Locality Ab-9

Locality Ab-9 is equivalent to GSC locality C-136491. The sample is from a very thin, light green, concretionary, micritic limestone bed, 0.1 m thick, overlain and underlain be dark shale, 9.4 to 9.5 m above the base of the section, Long Rapids Formation. The location is the same as for locality Ab-"11" (= GSC loc. C-136485).

Conodonts identified by T.T. Uyeno are listed in Figure 7.

Locality Ab-10

Locality Ab-10 is equivalent to GSC locality C-136492. Sample from a hard, concretionary, pale green to yellow limestone bed, 0.1 m thick, overlain by black shale, underlain by green mudstone, containing finely macerated shell fragments including echinoderm columnals, 9.9 to 10.0 m above the base of the section, Long Rapids Formation. The location is the same as for locality Ab-"11" (= GSC loc. C-136485).

Conodonts identified by T.T. Uyeno are listed in Figure 7.

Locality Ab-12

Locality Ab-12 is equivalent to GSC locality C-136493. The sample is from a greenish grey micritic limestone, 0.3 m thick, overlain by brown, blocky shale, underlain by green mudstone, containing brachiopods, 17.1 to 17.4 m above the base of the section, Long Rapids Formation. The location is the same as for locality Ab-"11" (= GSC loc. C-136485).

Megafossil described from this locality by P. Sartenaer:

Calvinaria sp. cf. *C. ambigua* (Calvin, S., 1878)

Conodonts identified by T.T. Uyeno are listed in Figure 7.

GSC locality 6570

The sample from GSC locality 6570 has Field No. XVII. It is 8 ft. (2.4 m) of green limestone, a short distance above the Huron Shale (= Long Rapids Formation), just below the lowest island of a series at the foot of Long Rapids, Abitibi River, Ontario.

Collected by M.Y. Williams, August 29, 1919 (information obtained from sample label).

Fossils identified by Williams from this locality include (determinations by A.W. Norris in brackets):

Chonetes sp. (*Strophodonta* sp.)
Leiorhynchus sp. A new (*Calvinaria* sp. A)
Hypothyridina sp. (*Hypothyridina*? sp. A)

According to the reports by Williams (1920a, p. 26, 1920b, p. 8) these fossils came from an outcrop along the west bank of the Abitibi River opposite the large limestone island (later named Williams Island) near the foot of the rapids (more correctly about the middle of Long Rapids). A composite section given by Williams (1920a, b) for this locality, in ascending sequence, is as follows: 20 ft. (6.1 m) of heavy, unevenly bedded limestone, of Onondaga age; probably 6 or 7 ft. (1.8 or 2.1 m) of green argillaceous shale; about 8 to 10 ft. (2.4 to 3.04 m) of brown to black shale; 2 ft. (0.61 m) of green limestone with shale partings and a considerable amount of pyrite. According to Williams (1920a, b), it is this upper limestone bed that contains *Hypothyris cuboides* (Sowerby) and *Leiorhynchus*(?) sp., which on the basis of the former fossil he considered to be equivalent to the Tully Limestone of New York State and also considered to mark the base of the Upper Devonian. Because of the emphasis placed on *Hypothyridina* sp. and *Calvinaria* sp., these species are described and illustrated in this report.

There is a slight discrepancy in information on location and thickness data provided on the label for GSC locality 6570 and the two reports of Williams (1920a, b) describing this locality.

In recognition of the work of M.Y. Williams, Kindle (1924, p. 34, 35) proposed the name "Williams Island" for the large island in Abitibi River near the foot of Long Rapids, and the name "Williams Island Limestone" for the carbonate and shale exposed on the island. The 2 ft. (0.61 m) interval of green limestone containing *Hypothyridina* exposed on the west bank of the river opposite the island was also included in the uppermost part of the Williams Island Formation.

PLATE 1

All illustrated specimens are from the uppermost member of the Williams Island Formation

Figures 1-16. *Schizophoria* sp. cf. *S. athabaskensis* Warren

1-5. Brachial, pedicle, lateral, posterior, and anterior views, x1, of a young adult shell, hypotype ROM 47267, locality Ab-"11".

6-10. Brachial, pedicle, lateral, posterior, and anterior views, x1, of a juvenile shell, hypotype ROM 47268, locality Ab-"11".

11-15. Pedicle, x1, brachial, x1, lateral, x2, posterior, x2, and anterior, x1, views of a juvenile shell, hypotype ROM 47269, locality Ab-"11".

16. View of interior, x3, of an incomplete, juvenile brachial valve, hypotype ROM 47270, locality Ab-"11".

Figures 17-33. *Strophodonta* (*Strophodonta*) *abitibiensis* Norris n. sp.

17-21. Pedicle, brachial, posterior, lateral, and anterior views, x1, of a large, adult shell with extended cardinal angles, holotype ROM 47271, locality Ab-"11".

22-24. Exterior, x1, x2, and interior, x2, views of a pedicle valve of a small, rotund, adult shell, paratype ROM 47272, locality Ab-"11".

25-28. Exterior, x1, x2, and interior, x1, x2, views of a brachial valve of a small, adult shell showing a high peripheral rim on interior of valve, paratype ROM 47273, locality Ab-"11".

29-33. Exterior, x1, x2, interior, x2, posterior, x1, and lateral, x2, views of a pedicle valve of a small, adult shell, paratype ROM 47274, locality Ab-"11".

Figures 34-37. *Nervostrophia ralla* Norris n. sp.

34-37. Exterior, x2, x3, and interior, x2, x3, views of the pedicle valve of an elongate adult shell, paratype ROM 47275, locality Ab-"11".

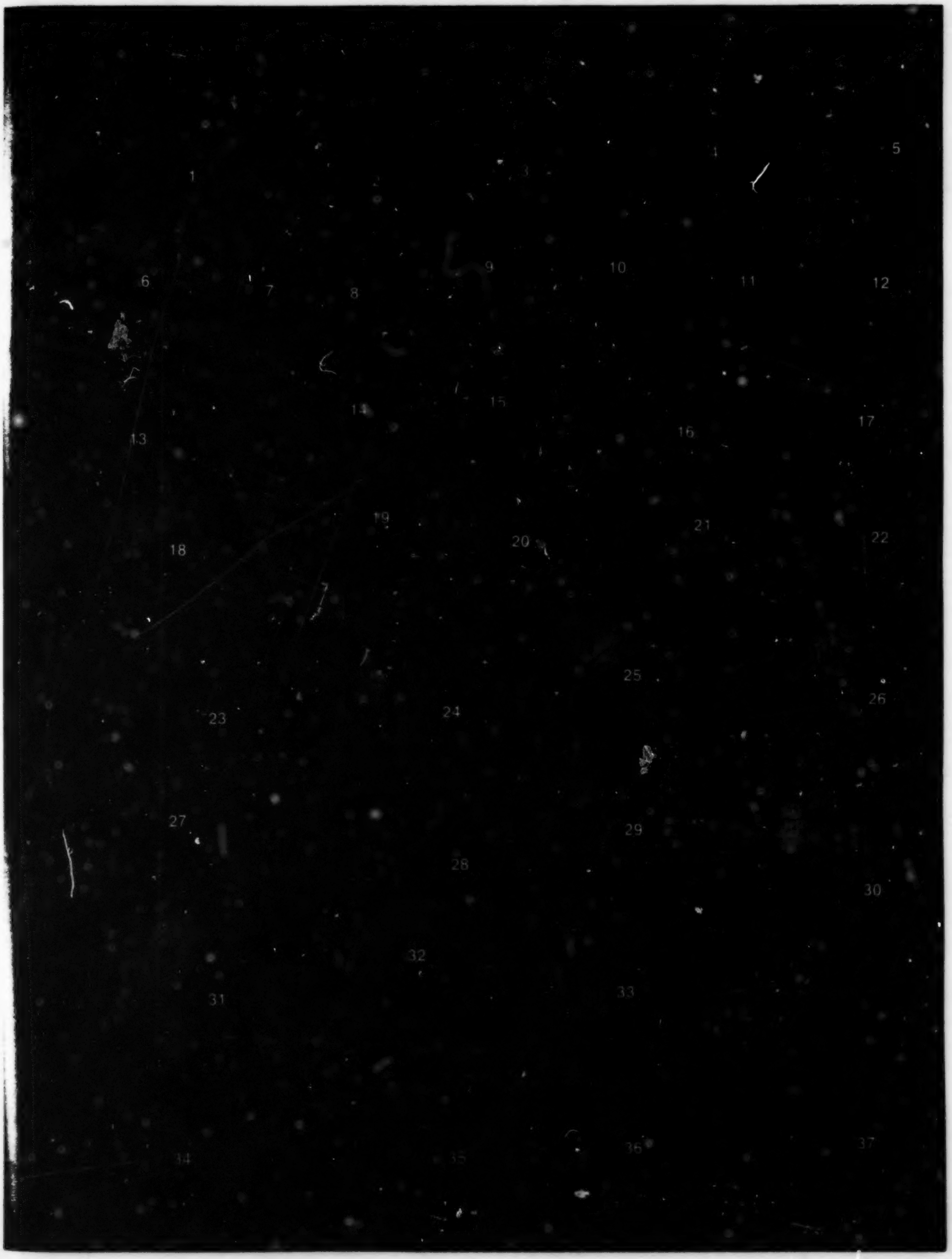
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PLATE 2

All illustrated specimens are from the uppermost member of the Williams Island Formation

Figures 1–7. *Nervostrophia ralla* Norris n. sp.

1, 2. Exterior, x2, x3, views of brachial valve of adult shell, with a smaller specimen attached to and partly covering the pedicle valve, holotype ROM 47276, locality Ab-"11".

3, 4. Exterior, x2, x3, views of pedicle valve of young adult shell attached to holotype ROM 47276, paratype ROM 47277, locality Ab-"11".

5–7. Pedicle, x3, x2, and brachial, x3, views of an incomplete, wide, adult shell, paratype ROM 47278, locality Ab-"11".

Figures 8–29. *Eostrophalosia parksi* Norris n. sp.

8–10. Pedicle, x2, x3, and lateral, x3, views of a large, broad, adult shell, paratype ROM 47279, locality Ab-"11".

11–14. Pedicle, x2, x3, and brachial, x3, x2, views of a nearly complete, adult shell, holotype ROM 47280, locality Ab-"11".

15–21. Pedicle, x3, x2, brachial, x2, x3, lateral, x2, posterior, x3, and anterior, x2, views of an elongate, adult shell, paratype ROM 47281, locality Ab-"11".

22–29. Posterior, x2, x3, anterior, x2, lateral, x2, pedicle, x2, x3, and brachial, x2, x3, views of a young adult shell, paratype ROM 47282, locality Ab-"11".

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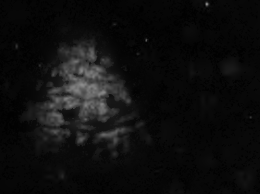
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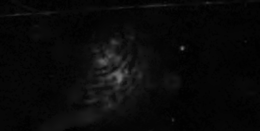
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PLATE 3

All illustrated specimens are from the uppermost member of the Williams Island Formation, unless otherwise undicated

Figures 1–18. *Ladogioides pusilla* Sartenaer n. sp.

1–9. Pedicle, x3, x2, brachial, x2, x3, anterior, x2, x3, posterior, x2, and lateral, x3, x2, views of a wide, adult shell, paratype ROM 47285, locality Ab-"11".

10–18. Pedicle, x2, x3, brachial, x3, x2, anterior, x2, x3, oblique posterior, x2, and lateral, x2, x3, views of an elongate, adult shell, holotype ROM 47286, locality Ab-"11".

Figures 19–28. *Calvinaria* sp. cf. *C. ambigua* (Calvin, S., 1878)

19–23. Pedicle, brachial, posterior, anterior, and lateral views, x1, of a thin, adult shell, hypotype ROM 47288, locality Ab-12 (Long Rapids Formation).

24–28. Pedicle, brachial, lateral, posterior, and anterior views, x1, of a thick, adult shell, hypotype ROM 47289, locality Ab-12, stratigraphic and locality data same as for hypotype ROM 47288.

Figures 29–33. *Leiorhynchus quadracostatus alces* Sartenaer n. subsp.

29–33. Pedicle, x1, x2, brachial, x2, posterior, x2, and lateral, x2, views of a young, thin shell, costal formula: 6/5; 0; 0, paratype ROM 47304, locality Ab-"11".

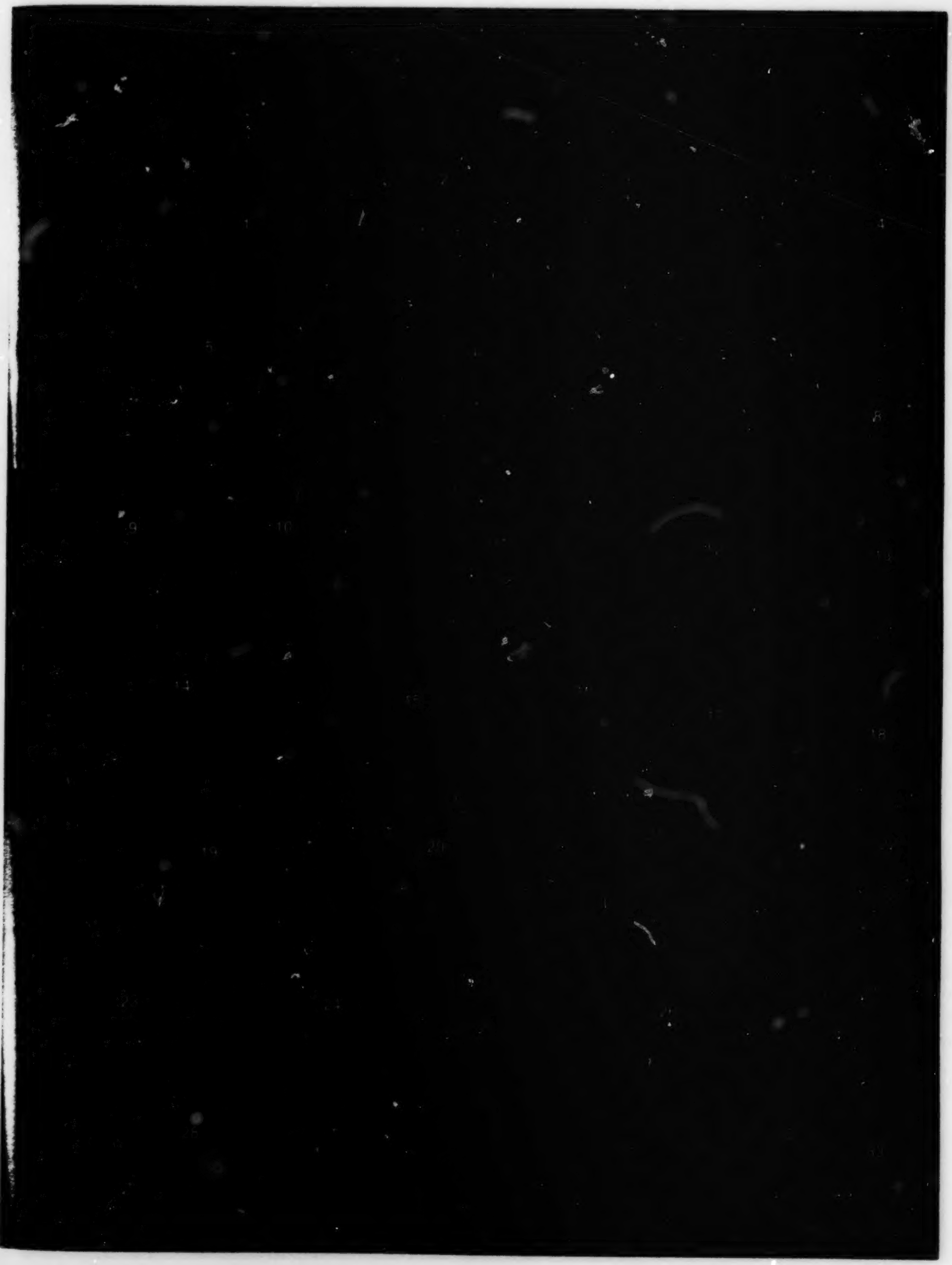
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PLATE 4

All illustrated specimens are from the uppermost member of the Williams Island Formation

Figures 1-36. *Leiorhynchus quadracostatus alces* Sartenaer n. subsp.

1-6. Pedicle, x1, brachial, x1, x2, lateral, x1, posterior, x1, and anterior, x1, views of a relatively smooth, young adult shell, costal formula: 5/?; 0; 0, paratype ROM 47293, locality Ab-"11".

7-11. Pedicle, brachial, posterior, lateral, and anterior, x1, views of an elongate, adult shell, costal formula: 5/4; 0; 0, paratype ROM 47294, locality JM-1 (presumably from uppermost Williams Island Formation).

12-16. Pedicle, brachial, lateral, posterior, and anterior, x1, views of a relatively small, elongate, adult shell, costal formula: 6/5; 0; 5/6, paratype ROM 47295, locality JM-1, stratigraphic and locality data same as for ROM 47294.

17-21. Pedicle, brachial, lateral, posterior, and anterior, x1, views of a circular, adult shell, costal formula: 4/3; 0; 0, paratype ROM 47296, locality JM-1, stratigraphic and locality data same as for ROM 47294.

22-26. Pedicle, brachial, lateral, posterior, and anterior, x1, views of a small, rotund, adult shell, costal formula: 4/?; 0; 0, paratype ROM 47297, locality JM-1, stratigraphic and locality data same as for ROM 47294.

27-31. Pedicle, brachial, lateral, posterior, and anterior, x1, views of a small, elongate, adult shell, costal formula: 3/2; 0; 2/3, paratype ROM 47298, locality JM-1, stratigraphic and locality data same as for ROM 47294.

32-36. Pedicle, brachial, lateral, posterior, and anterior, x1, views of a circular, thick, adult shell, costal formula: 6/5; 0; 0, holotype ROM 47300, locality JM-1, stratigraphic and locality data same as for ROM 47294.

Figures 37-43. *Atryparia rubra* Cooper and Dutro

37-39. Pedicle, brachial, and anterior, x1, views of a mature adult shell with some preserved alate lamellae, hypotype ROM 47305, locality Ab-"11".

40-42. Posterior, brachial, and lateral, x1, views of an elongate, adult shell, hypotype ROM 47306, locality Ab-"11".

43. Pedicle, x1, view of a young adult shell, hypotype ROM 47307, locality Ab-"11". (Other views of this specimen are given in Plate 5.)

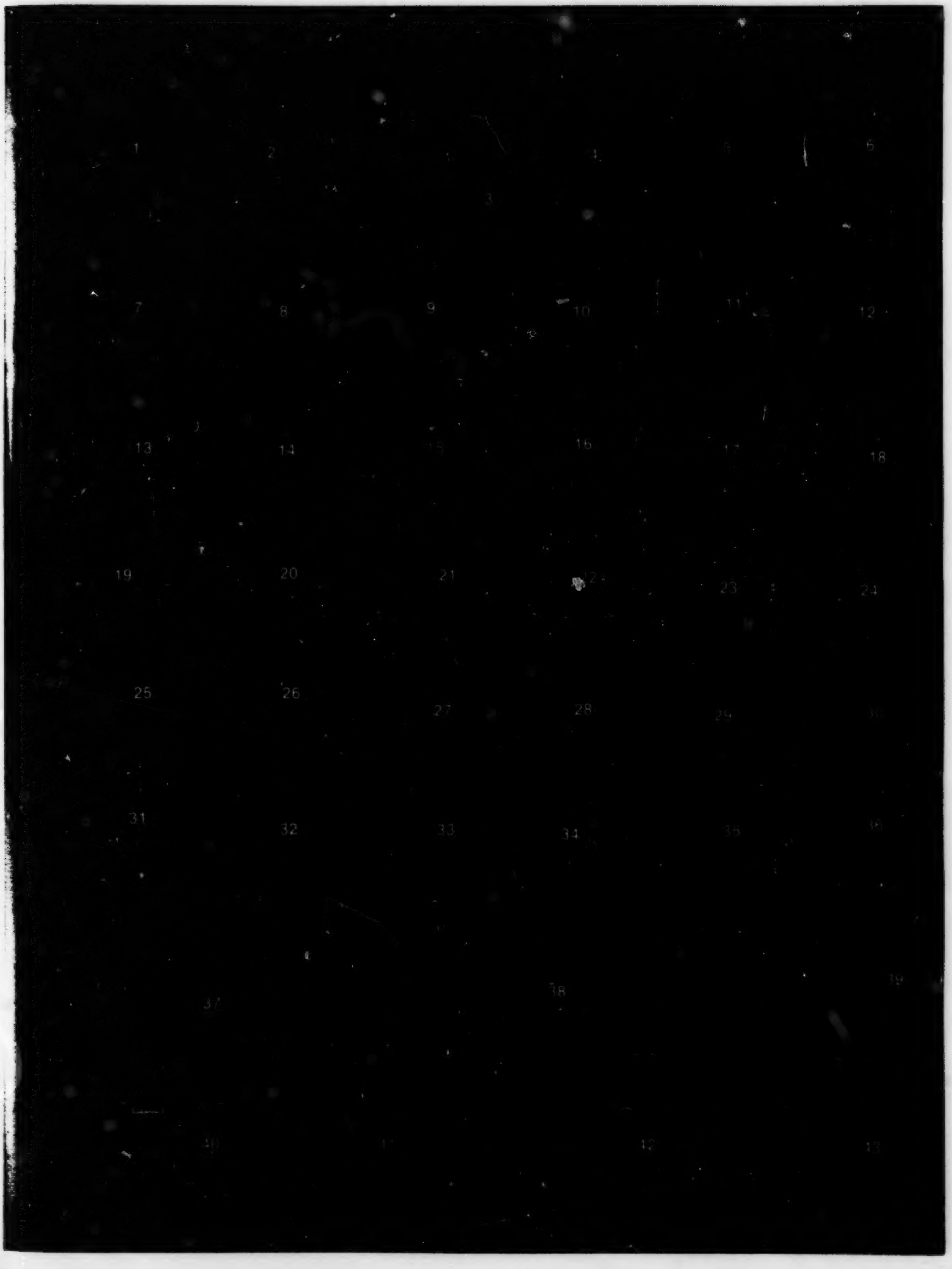
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PLATE 5

All illustrated specimens are from the uppermost member of the Williams Island Formation

Figures 1–13. *Atryparia rubra* Cooper and Dutro

- 1–4. Brachial, lateral, posterior, and anterior, x1, views of a young adult shell, hypotype ROM 47307, locality Ab-"11". (Pedicle view in Plate 4, fig. 43.)
- 5–13. Brachial (figs. 5, 7; x1, x2), pedicle (figs. 6, 9; x2, x1), lateral (fig. 8; x1), posterior (figs. 10, 11; x1, x2), and anterior (figs. 12, 13; x1, x2) views of a young, wide adult shell, hypotype ROM 47308, locality Ab-"11".

Figures 14–39. ***Desquamatia (Independatrypa) exila*** Norris n. sp.

- 14–19. Pedicle, x1, x2, brachial, x1, x2, lateral, x1, x2, views of a mature, thin, adult shell, paratype ROM 47310, locality Ab-"11".
- 20–26. Pedicle, x1, x2, brachial, x1, x2, lateral, x1, x2, and posterior, x2, views of a broad, thin, young adult shell, holotype ROM 47311, locality Ab-"11".
- 27–32. Pedicle, x2, x1, brachial, x1, lateral, x1, posterior, x1, and anterior, x1, views of a young, relatively thick, elongate shell, paratype ROM 47312, locality Ab-"11".
- 33–39. Pedicle, x1, x2, lateral, x1, x2, brachial, x2, posterior, x2, and anterior, x2, views of a young, elongate shell, paratype ROM 47313, locality Ab-"11".

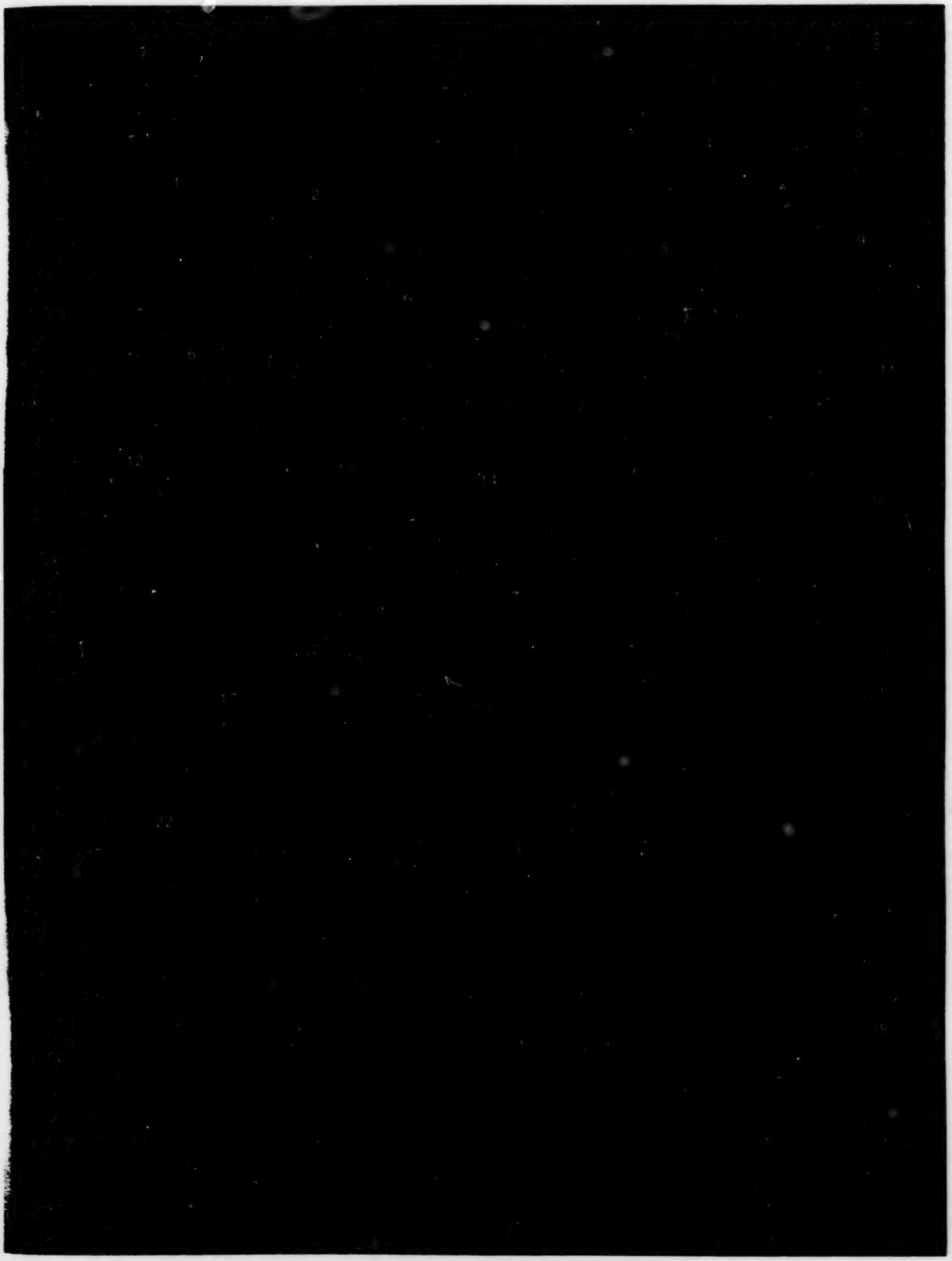
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PLATE 6

All illustrated specimens are from the uppermost member of the Williams Island Formation

Figures 1-19. *Desquamatia* (*Independatrypa*) sp. A

1-8. Pedicle, x1, x2, brachial, x1, x2, lateral, x1, x2, anterior, x2, and posterior, x2, views of a relatively thick, mature adult shell with a trigonal outline, hypotype ROM 47316, locality Ab-"11".

9-12. Brachial, x2, x1, and lateral, x1, x2, views of a relatively thick, young adult shell with a subquadrate outline, hypotype ROM 47317, locality Ab-"11".

13-19. Pedicle, x1, x2, brachial, x1, x2, anterior, x2, lateral, x2, and posterior, x2, views of a relatively thin, young adult shell, hypotype ROM 47318, locality Ab-"11".

Figures 20-29. *Desquamatia* (*Independatrypa*) sp. B

20-24. Pedicle, x2, x1, brachial, x2, lateral, x2, and posterior, x2, views of an elongate, oval, adult shell, hypotype ROM 47319, locality Ab-"11".

25-29. Pedicle, x1, x2, brachial, x2, posterior, x2, and lateral, x2, views of a relatively thick, adult shell with a ventrally directed marginal frill, hypotype ROM 47320, locality Ab-"11".

Figures 30-35. *Spinatrypa* (*Spinatrypa*) sp. A

30-35. Pedicle, x1, x2, brachial, x2, lateral, x2, posterior, x2, and anterior, x2, views of a mature adult shell, hypotype ROM 47321, locality Ab-"11".

Figures 36-42. *Spinatrypa* (*Spinatrypa*) *tribulosa* Norris n. sp.

36-42. Pedicle, x1, x2, lateral, x2, posterior, x2, brachial, x2, and anterior, x2, x3, views of a relatively thick, subovate, adult shell showing spines, paratype ROM 47322, locality Ab-"11".

PLATE 7

All illustrated specimens are from the uppermost member of the Williams Island Formation

Figures 1–18. *Spinatrypa (Spinatrypa) tribulosa* Norris n. sp.

1–6. Pedicle, x1, x2, brachial, x2, lateral, x2, posterior, x2, and anterior, x2, views of a relatively thick, adult shell, holotype ROM 47323, locality Ab-"11".

7–12. Pedicle, x3, x1, brachial, x2, lateral, x2, posterior, x3, and anterior, x2, views of an elongate, subovate, young shell, paratype ROM 47324, locality Ab-"11".

13–18. Pedicle, x1, x2, brachial, x2, lateral, x2, posterior, x2, and anterior, x2, views of a relatively thin, subheptagonal, adult shell showing spines, paratype ROM 47325, locality Ab-"11".

Figures 19–33. *Emanuella martisoni* Norris n. sp.

19–24. Pedicle, x2, brachial, x2, lateral, x2, posterior, x2 and anterior, x2, views of thick, rotund shell, and an enlarged view, x6 of exterior of pedicle valve showing spine-like micro-ornament, holotype ROM 47328, locality Ab-"11".

25–30. Pedicle, x2, x3, brachial, x3, lateral, x3, and anterior, x3, views of a small, young shell, and an enlarged, x6, view of exterior of pedicle valve showing micro-ornament, paratype ROM 47329, locality Ab-"11".

31–33. Exterior, x1, x2, and interior, x2, views of pedicle valve of a large, adult shell, paratype ROM 47330, locality Ab-"11".

Figures 34–50. *Ladjia? plicata* Norris n. sp.

34–41. Pedicle, x3, x2, brachial, x2, x3, lateral, posterior, and anterior, x3, views of a wide, mature adult shell, and an enlarged, x6, view of exterior of brachial valve showing micro-ornament, holotype ROM 47332, locality Ab-"11".

42–50. Pedicle, x2, x3, brachial, x2, x3, lateral, x3, posterior, x2, x3, and anterior, x2, x3, views of an elongate, young adult shell, paratype ROM 47333, locality Ab-"11".

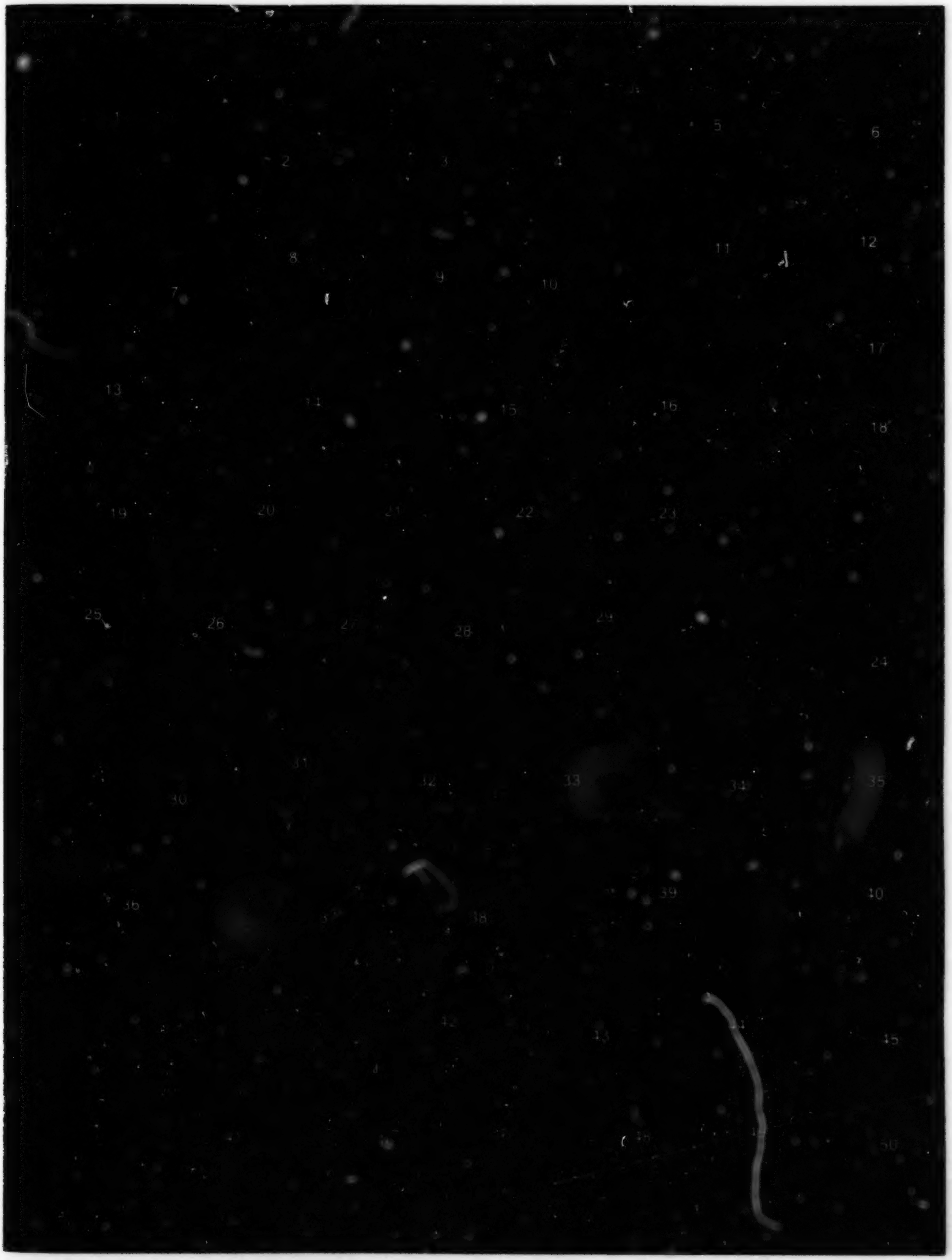
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PLATE 8

All illustrated specimens are from the uppermost member of the Williams Island Formation

Figures 1–28. *Cyrtina* sp. aff. *C. triquetra* (Hall)

1–8. Pedicle, x2, x3, brachial, x2, x3, lateral, x2, x3, and posterior, x2, x3, views of a mature adult shell, hypotype ROM 47334, locality Ab-"11".

9–18. Pedicle, x2, x3, brachial, x2, x3, lateral, x3, x2, posterior, x2, x3, and anterior, x2, x3, views of a young, narrow, elongate shell, hypotype ROM 47335, locality Ab-"11".

19–28. Pedicle views, x2, x5 (latter view shows micro-ornament on exterior of valve), brachial, x3, x2, lateral, x3, x2, posterior, x2, x3, and anterior, x2, x3, views of a young, wide shell, hypotype ROM 47336, locality Ab-"11".

Figures 29–50. *Tecnocyrtina bicostata* Norris n. sp.

29–37. Pedicle views, x2, x5 (latter view shows micro-ornament on exterior of valve), brachial, x2, x3, lateral, x2, x3, posterior, x2, x3, and anterior, x3, views of a large, elongate, adult shell, paratype ROM 47339, locality Ab-"11".

38–47. Pedicle, x2, x3, brachial, x3, x2, lateral x3, x2, anterior, x2, x3, and posterior, x2, x3, views of a wide, adult shell, holotype ROM 47340, locality Ab-"11".

48–50. Pedicle, x2, x3, and brachial, x2, views of a small, elongate shell, paratype ROM 47341, locality Ab-"11". (Other views of this specimen are given in Plate 9.)

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PLATE 9

All illustrated specimens are from the uppermost member of the Williams Island Formation

Figures 1-7. *Tecnocyrtina bicostata* Norris n. sp.

1-7. Brachial, x3, lateral, x2, x3, posterior, x2, x3, and anterior, x2, x3, views of a small, elongate shell, paratype ROM 47341, locality Ab-"11". (Continued from Plate 8.)

Figures 8-37. *Mucrospirifer williamsi* Norris n. sp.

8-17. Pedicle, x2, x3, brachial, x3, x2, lateral, x2, x3, posterior, x2, x3, and anterior, x2, x3, views of a wide, adult shell, (form B), paratype ROM 47344, locality Ab-"11".

18-25. Pedicle, x2, x5 (latter view shows micro-ornament on exterior of valve), brachial, x2, x3, lateral, x2, x3, and anterior, x2, x3, views of a narrow, adult shell (form A), holotype ROM 47345, locality Ab-"11".

26, 27. Exterior, x5, and interior, x5, views of an incomplete pedicle valve of a young, narrow shell (form A), paratype ROM 47346, locality Ab-"11".

28-33. Exterior, x2, x3, interior, x5, x3, oblique interior, x5, and posterior, x3, views of an incomplete pedicle valve of a wide, adult shell (form B), paratype ROM 47347, locality Ab-"11".

34-37. Exterior, x3, interior, x3, x5, and oblique interior, x5, views of an incomplete brachial valve of a young, narrow shell (form B), paratype ROM 47348, locality Ab-"11".

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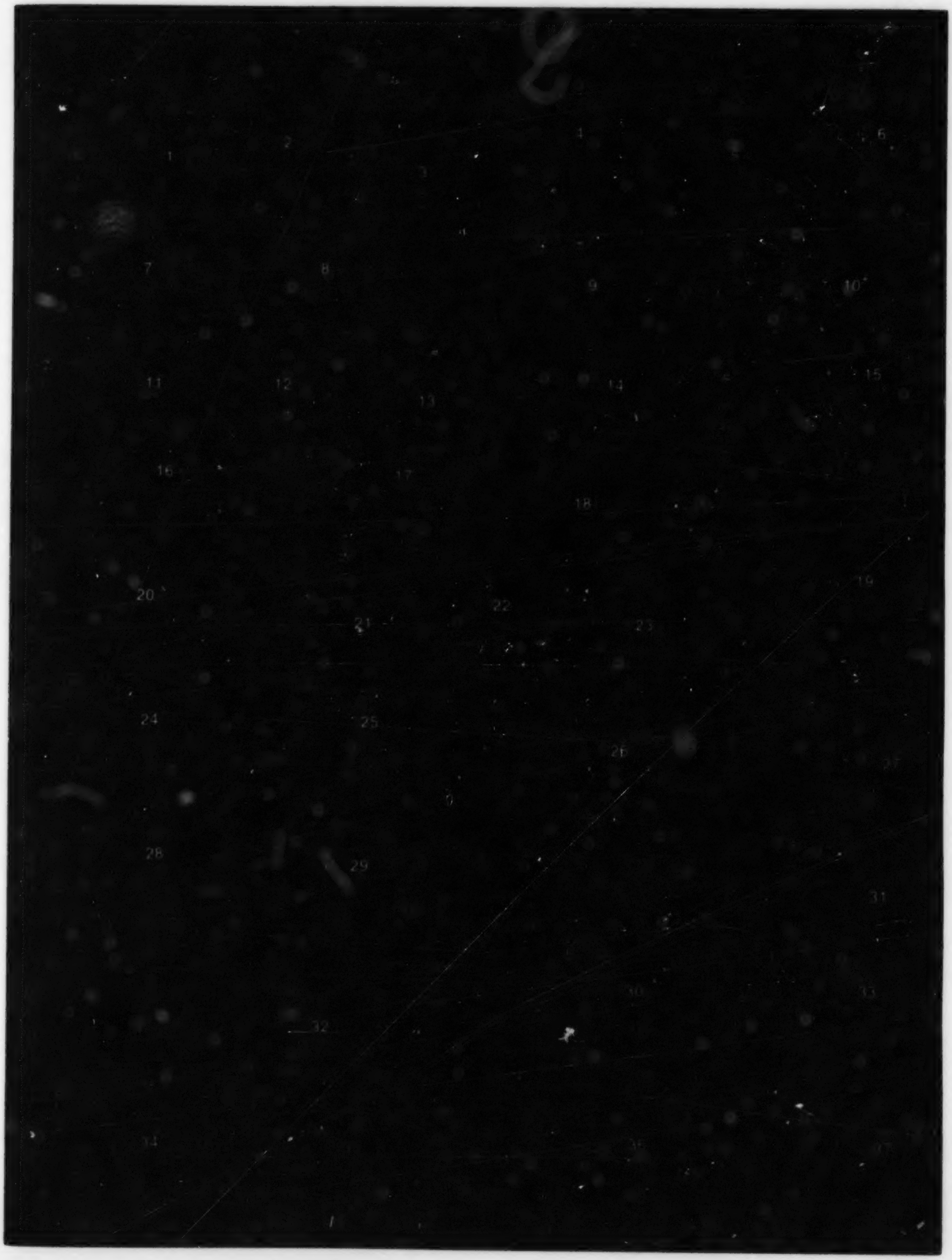
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PLATE 10

All illustrated specimens are from the Long Rapids Formation

Figures 1–6. *Hypothyridina*? sp. A

1–6. Brachial, x2, x1, pedicle, x1, lateral, x1, x2, and posterior, x1, views of an incomplete, poorly preserved specimen, hypotype GSC 94273, GSC loc. 6570 (Field No. XVII), from the west bank of Abitibi River opposite Williams Island, collected by M.Y. Williams, August 29, 1919, associated with *Calvinaria* sp. A.

Figures 7–14. Calvinariid sp.

7–14. Pedicle, x2, brachial, x2, x1, lateral, x1, posterior, x2, x1, and anterior, x2, x1, views of an almost complete, mature individual, hypotype ROM 47290, GSC loc. 100799 (= locality Ab-6), associated with *Manticoceras* sp. cf. *M. sinuosum* (Hall).

Figure 15. *Calvinaria* sp. A

View of an incomplete pedicle valve of an adult individual embedded in matrix, x1, hypotype GSC 94274, GSC loc. 6570 (Field No. XVII), from west bank of Abitibi River opposite Williams Island, collected by M.Y. Williams, August 19, 1919, associated with *Hypothyridina*? sp. A.

The following specimens are illustrated by scanning electron microscope micrographs. The specimens are from acid residues of a carbonate bed in the Long Rapids Formation [containing *Manticoceras* sp. cf. *M. sinuosum* (Hall)], which was treated for conodont analysis.

Figures 16–18. *Lingula* sp.

16, 17. Exterior and interior views, x28, of ventral valve of a young adult individual, hypotype ROM 47262, GSC loc. 100799 (locality Ab-6).

18. Interior view, x28, of dorsal valve of a young adult individual, hypotype ROM 47263, GSC loc. 100799. (Another view of this specimen is shown in Plate 11, figure 1.)

Figures 19–23. *Lingulipora* sp.

19, 20. Interior, x120, and exterior, x120, views of dorsal valve of a young adult individual, hypotype ROM 47264, GSC loc. 100799. (Another view of this specimen is shown in Plate 11, figure 2.)

21, 22. Interior, x33, and exterior, x33, views of ventral valve of a young adult individual, hypotype ROM 47265, GSC loc. 100799.

23. Interior view, x24, of part of a valve showing punctae of inner layer of valve, hypotype ROM 47266, GSC loc. 100799. (Another view of this specimen is shown in Plate 11, figure 3.)

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PLATE 11

The following specimens are illustrated by scanning electron microscope micrographs. All specimens are from the goniatite bed of the Long Rapids Formation

Figure 1. *Lingula* sp.

Greatly magnified, x120, view of part of interior of a dorsal valve showing inner layer of valve without punctae, hypotype ROM 47263, GSC loc. 100799 (locality Ab-6). (Continued from Plate 10.)

Figures 2, 3. *Lingulipora* sp.

2. Greatly magnified, x130, view of part of interior of dorsal valve showing inner layer of valve with coarse punctae, hypotype ROM 47264, GSC loc. 100799 (locality Ab-6). (Continued from Plate 10.)
3. Greatly magnified, x100, view of part of interior of a valve showing inner layer of valve with coarse punctae, hypotype ROM 47266, GSC loc. 100799 (locality Ab-6). (Continued from Plate 10.)

PLATE 12

Specimens in figures 1-4 are from the Williams Island Formation; all other illustrated specimens are from the Long Rapids Formation

Figures 1-4. *Palmatolepis* sp. indet.

1, 2. Upper and lower views of Pa element, x80, ROM 47351, GSC loc. C-136485.

3, 4. Lower and upper views of Pa element, x65, ROM 47352, GSC loc. C-136485.

Figures 5, 6. *Palmatolepis* sp. A

5. Inner lateral view of Pb element, x85, ROM 47353, GSC loc. C-136488.

6. Upper view of Pa element, x40, ROM 47354, GSC loc. C-136488.

Figures 7-19. *Palmatolepis kireevae* Ovnatanova

7. Inner lateral view of Pb element, x60, ROM 47355, GSC loc. 100799.

8, 14. Inner lateral views of two Pb elements, x50, x55, ROM 47357, 47358, GSC loc. C-136490.

9. Inner lateral view of Pb element, x80, ROM 47361, GSC loc. C-136491.

10. Upper view of Pa element, x31, ROM 47356, GSC loc. 100799.

11. Upper view of Pa element, x40, ROM 47359, GSC loc. C-136490.

12. Inner lateral view of M element, x50, ROM 47360, GSC loc. C-136490.

13, 15. Inner lateral views of two M elements, both x47, ROM 47362, 47363, GSC loc. C-136491.

16. Upper view of Pa element, x47, ROM 47364, GSC loc. C-136491.

17. Upper view of Pa element, x42, ROM 47365, GSC loc. C-136493.

18, 19. Inner lateral views of two M elements, both x50, ROM 47366, 47367, GSC loc. C-136493.

Figures 20, 21. *Palmatolepis* sp. cf. *P. kireevae* Ovnatanova

20. Upper view of Pa element, x40, ROM 47368, GSC loc. C-136491.

21. Upper view of Pa element, x26, ROM 47369, GSC loc. C-136490.

Figure 22. *Palmatolepis domanicensis* Ovnatanova

Upper view of Pa element, x55, ROM 47370, GSC loc. C-136490.

Figures 23, 24. *Palmatolepis unicornis* Miller and Youngquist

Upper views of two Pa elements, both x31, ROM 47371, 47372, GSC loc. C-136490.

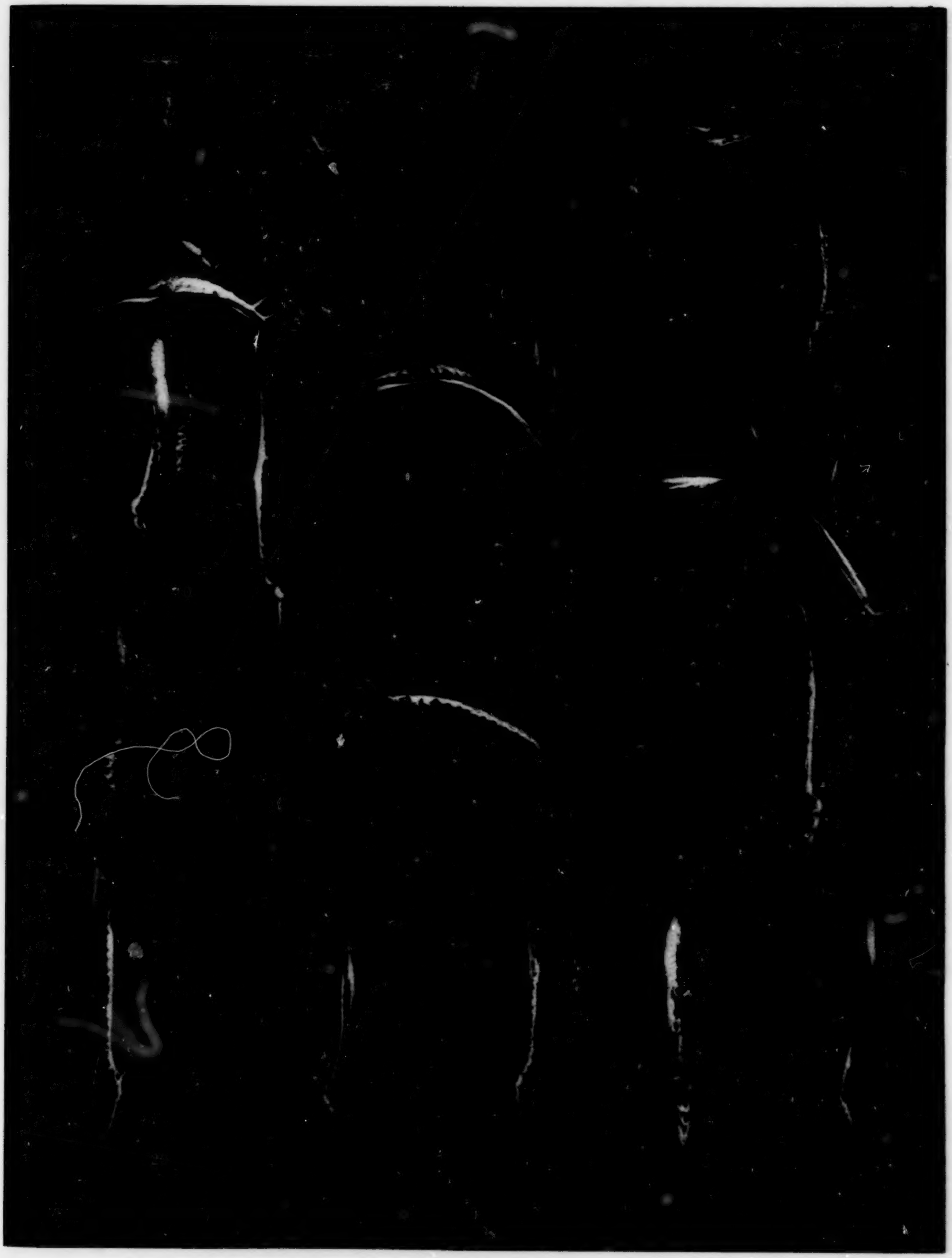

PLATE 13

Specimens in figures 1-15 are from the long Rapids Formation; all other illustrated specimens are from the Williams Island Formation

Figures 1–8, 10. *Palmatolepis winchelli* (Stauffer)

1, 4, 5. Upper views of three Pa elements, x40, x35, x28, ROM 47373, 47374, 47375, respectively, GSC loc. C-136493.

2, 3, 6, 10. Inner lateral views of four Pa elements, x50, x50, x37, x37, ROM 47376, 47377, 47378, 47379, respectively, GSC loc. C-136493.

7, 8. Inner lateral views of two M elements, x80, x50, ROM 47380, 47381, GSC loc. C-136493.

Figures 9, 14, 15. *Palmatolepis* sp. aff. *P. rhenana* (Bischoff)

Upper views of three Pa elements, x30, x30, x26, ROM 47382, 47383, 47384, respectively, GSC loc. C-136493.

Figures 11, 12. *Palmatolepis* sp. cf. *P. foliacea* Youngquist

Upper views of two Pa elements, x47, x37, ROM 47385, 47386, GSC loc. C-136493.

Figure 13. *Palmatolepis foliacea* Youngquist

Upper view of Pa element, x47, ROM 47387, GSC loc. C-136493.

Figures 16–18. *Polygnathus dengleri* Bischoff and Ziegler

16, 17. Upper and lower views of Pa element, x55, ROM 47388, GSC loc. C-136486.

18. Upper view of Pa element, x65, ROM 47389, GSC loc. C-136487.

Figures 19–23. *Polygnathus pennatus* Hinde

19, 20. Upper views of two Pa elements, both x50, ROM 47390, 47391, GSC loc. C-136486.

21, 22. Lower and oblique upper views of Pa element, x50, ROM 47392, GSC loc. C-136486.

23. Upper view of Pa element, x42, ROM 47393, GSC loc. C-136487.

Figures 24–30. *Polygnathus dubius* Hinde

24, 25. Lower and oblique upper views of Pa element, x50, ROM 47394, GSC loc. C-136486.

26. Upper view of Pa element, x50, ROM 47396, GSC loc. C-136485.

27, 28. Upper and lower views of Pa element, x50, ROM 47395, GSC loc. C-136486.

29, 30. Lower and oblique upper views of Pa element, x37, ROM 47397, GSC loc. C-136487.

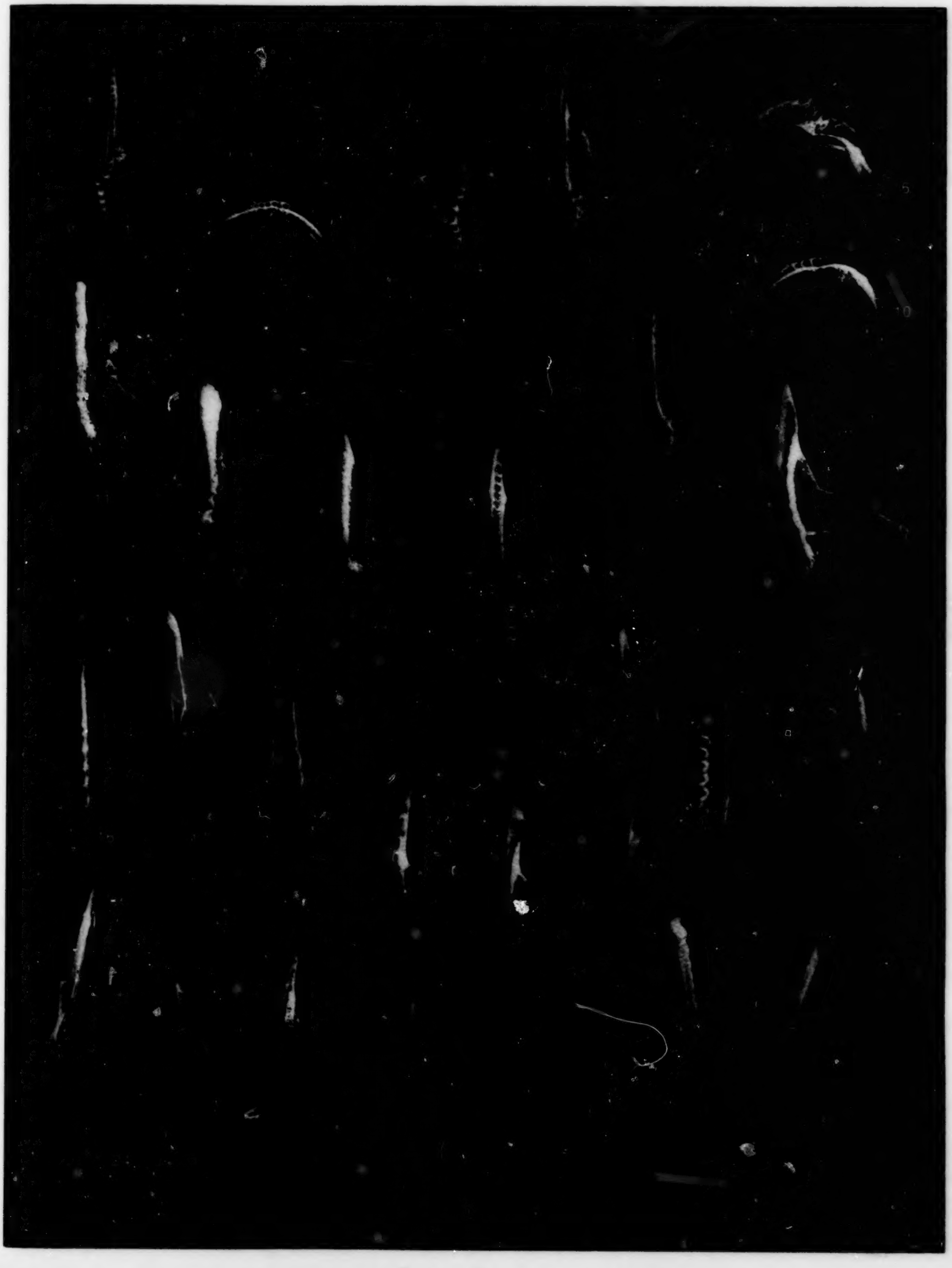
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PLATE 14

All illustrated specimens are from the Long Rapids Formation

Figures 1–8. *Polygnathus* sp. cf. *P. decorosus* Stauffer

1, 2. Oblique upper and lower views of Pa element, both x50, ROM 47398, GSC loc. 100799.

3, 4. Upper and lower views of Pa element, both x50, ROM 47399, GSC loc. 100799.

5, 6. Inner lateral and upper views of Pa element, both x42, ROM 47400, GSC loc. 100799.

7, 8. Upper and lower views of Pa element, x47, ROM 47401, GSC loc. 100799.

Figures 9–17. *Polygnathus decorosus* Stauffer

9. Oblique upper view of Pa element, x50, ROM 47402, GSC loc. C-136491.

10, 11. Upper and outer lateral views of Pa element, x35, ROM 47404, GSC loc. C-136490.

12, 13. Upper and lower views of Pa element, x35, ROM 47405, GSC loc. C-136490.

14, 15. Upper views of two Pa elements, x50, x55, ROM 47406, 47407, respectively, GSC loc. C-136493.

16, 17. Upper and lower views of Pa element, both x50, ROM 47403, GSC loc. C-136491.

Figures 19–21. *Polygnathus* sp. aff. *P. angustidiscus* Youngquist

19. Upper view of Pa element, x50, ROM 47409, GSC loc. C-136493.

20, 21. Oblique upper and lower views of Pa element, x55, ROM 47410, GSC loc. C-136493.

Figures 18, 22–29. *Polygnathus evidens* Klapper and Lane

18. Oblique upper view of Pa element, x47, ROM 47408, GSC loc. C-136493.

22, 23. Upper and lower views of Pa element, x50, ROM 47411, GSC loc. C-136491.

24, 25. Lower and upper views of Pa element, x40, ROM 47413, GSC loc. C-136490.

26. Upper view of Pa element, x50, ROM 47414, GSC loc. C-136490.

27, 28. Upper and outer lateral views of Pa element, x40, ROM 47415, GSC loc. C-136490.

29. Upper view of Pa element, x50, ROM 47412, GSC loc. C-136491.

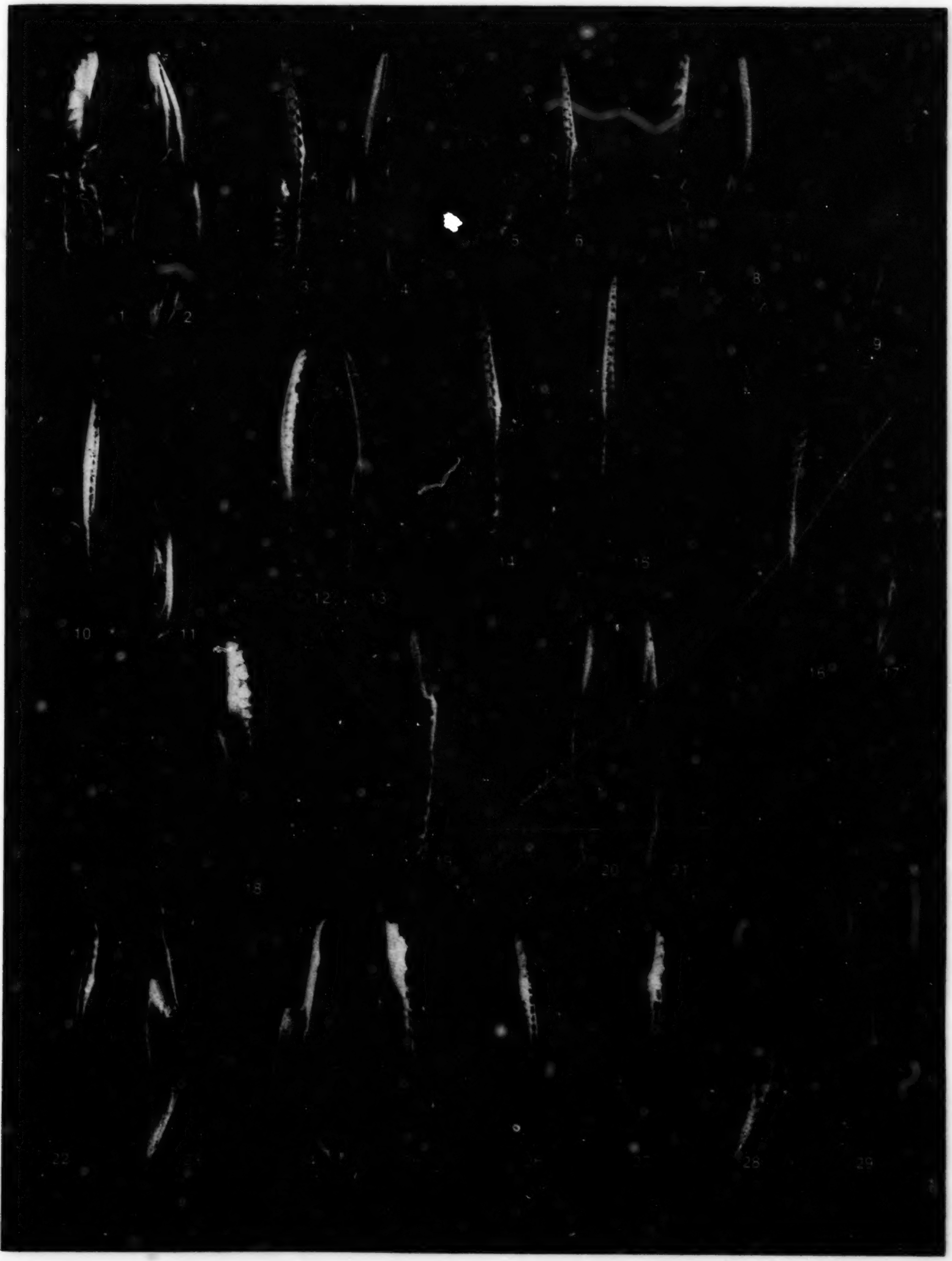
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PLATE 15

Specimens in figures 1-4, 9, 10 are from the Long Rapids Formation; all other illustrated specimens are from the Williams Island Formation

Figures 1-3. *Polygnathus* sp. cf. *P. aspelundi* Savage and Funai

1, 2. Upper and oblique outer lateral views of Pa element, x75, ROM 47416, GSC loc. C-136491.

3. Upper view of Pa element, x80, ROM 47417, GSC loc. C-136491.

Figure 4. *Polygnathus aspelundi* Savage and Funai

Upper view of Pa element, x75, ROM 47418, GSC loc. C-136493.

Figures 5, 6, 15, 16. *Ancyrodella rotundiloba* (Bryant) early form sensu Klapper (1985)?

5, 6. Lower and upper views of Pa element, x70, ROM 47419, GSC loc. C-136486.

15, 16. Upper and lower views of Pa element, x50, ROM 47420, GSC loc. C-136486.

Figures 7, 8. *Ancyrodella rotundiloba* (Bryant) early form sensu Klapper (1985)

Lower and upper views of Pa element, x55, ROM 47421, GSC loc. C-136486.

Figures 9, 10. *Polygnathus brevis* Miller and Youngquist sensu Szulczewski (1972)

Oblique upper and lower views of Pa element, x40, ROM 47422, GSC loc. C-136493.

Figures 11-14. *Ancyrodella alata* Glenister and Klapper early form sensu Klapper (1985)

11, 12. Lower and upper views of Pa element, x42, ROM 47423, GSC loc. C-136486.

13, 14. Upper and lower views of Pa element, x40, ROM 47424, GSC loc. C-136486.

Figures 17, 18, 21, 22. *Ancyrodella rotundiloba* (Bryant) late form sensu Klapper (1985)?

17, 18. Lower and upper views of Pa element, x42, ROM 47425, GSC loc. C-136486.

21, 22. Upper and lower views of Pa element, x33, ROM 47426, GSC loc. C-136486.

Figures 19, 20. *Ancyrodella rotundiloba* (Bryant) late form sensu Klapper (1985)

Lower and upper views of Pa element, x70, ROM 47427, GSC loc. C-136486.

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PLATE 16

Specimens in figures 7-9, 22 are from the Williams Island Formation; all other illustrated specimens are from the Long Rapids Formation

Figures 1–6. *Ancyrodella nodosa* Ulrich and Bassler

1, 2. Upper and lower views of Pa element, x40, ROM 47428, GSC loc. 100799.
3, 4. Upper and lower views of Pa element, x33, ROM 47429, GSC loc. 100799.
5. Upper view of Pa element, x50, ROM 47430, GSC loc. C-136491.
6. Upper view of Pa element, x33, ROM 47431, GSC loc. C-136490.

Figures 7–16. *Icriodus symmetricus* Branson and Mehl

7. Upper view of I element, x65, ROM 47432, GSC loc. C-136485.
8, 9. Upper and lower views of I element, x80, ROM 47433, GSC loc. C-136486.
10, 11. Lower and upper views of I element, x80, ROM 47434, GSC loc. 100799.
12, 15. Upper views of two I elements, x55, x75, ROM 47435, 47436, respectively, GSC loc. 100799.
13. Inner lateral view of S_{2a} element, x95, ROM 47437, GSC loc. 100799.
14. Inner lateral view of S_{2b} element, x95, ROM 47438, GSC loc. 100799.
16. Upper view of I element, x80, ROM 47439, GSC loc. C-136493.

Figures 17–24. *Mehlina*? sp. cf. *M. gradata* Youngquist

17, 18. Lateral views of two Pa elements, both x75, ROM 47440, 47441, respectively, GSC loc. C-136488.
19, 20, 23, 24. Lateral views of Pa elements, x55, x55, x50, x80, ROM 47442, 47443, 47444, 47445, respectively, GSC loc. 100799.
21. Lateral view of Pa element, x50, ROM 47446, GSC loc. C-136491.

Figure 22. *Mesotaxis* ex gr. *M. asymmetrica* (Bischoff and Ziegler)

Upper view of Pa element, x28, ROM 47447, GSC loc. C-136486.

Figure 25. *Mehlina* sp. sensu Klapper and Lane (1985)

Lateral view of Pa element, x50, ROM 47448, GSC loc. C-136493.

Figure 26. Ostracode, hollinid species

Lateral view, x47, ROM 47449, GSC loc. C-136493. (Identified by W.K. Braun.)

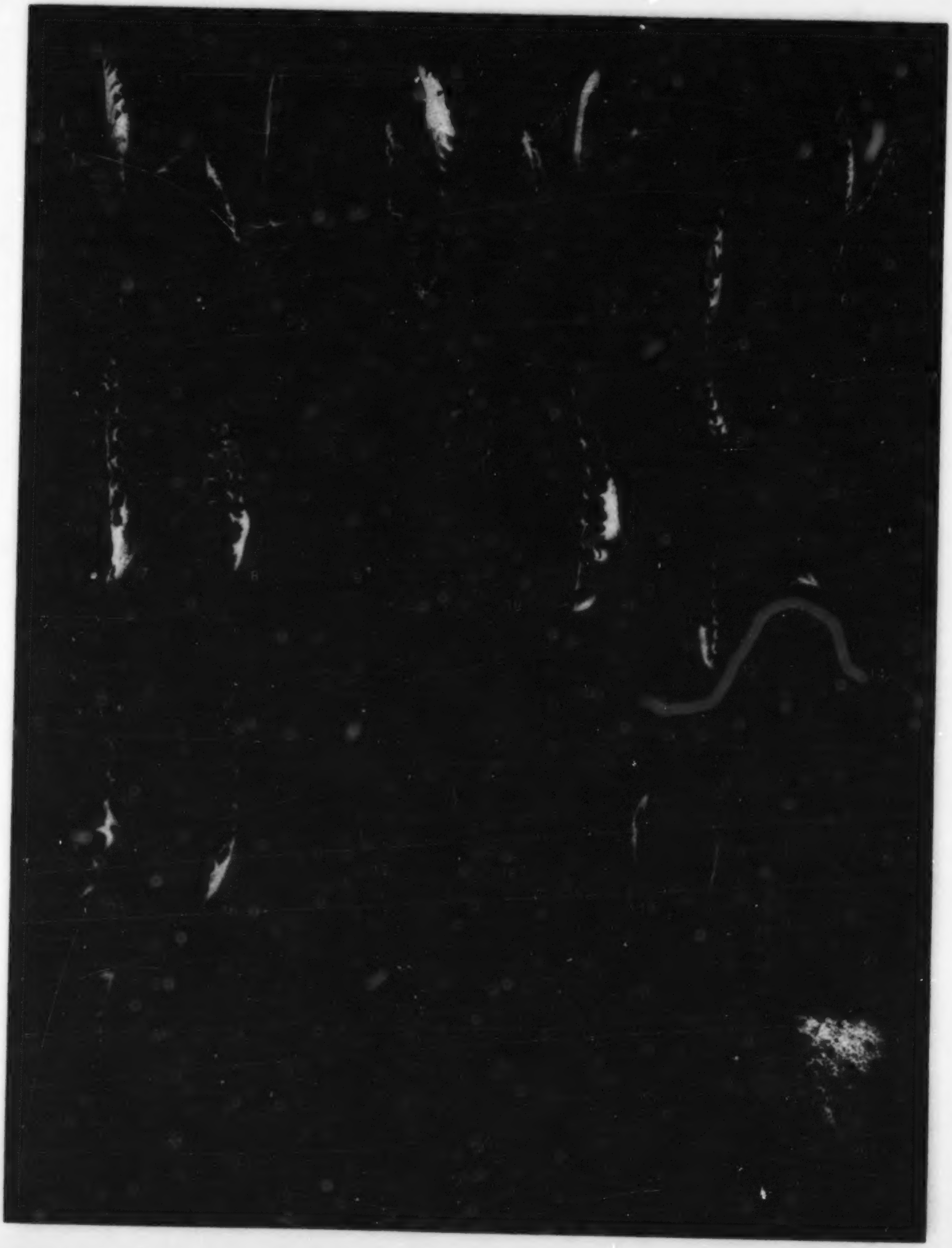
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PLATE 17

All illustrated specimens are from the Long Rapids Formation

Figure 1–4. *Ozarkodina postera* Klapper and Lane
- 1. Lateral view of Pa element, x90, ROM 47450, GSC loc. C-136490.
- 2, 3. Lateral views of two Pb elements, both x110, ROM 47451, 47452, GSC loc. C-136493.
- 4. Lateral view of Pa element, x120, ROM 47453, GSC loc. C-136493.

Figures 5, 6, 8, 9. *Ancyrognathus triangularis* Youngquist?
- 5, 6. Upper views of two small Pa elements, x95, x80, ROM 47454, 47455, GSC loc. 100799.
- 8, 9. Upper views of two small Pa elements, x50, x90, ROM 47457, 47458, GSC loc. C-136491.

Figure 7. *Ancyrognathus triangularis* Youngquist

Oblique upper view of Pa element, x16, ROM 47456, GSC loc. C-136490.

Figures 10–12, 16, 17, 21. *Oulodus*? sp.
- 10, 11. Inner lateral views of two Pb elements, both x47, ROM 47459, 47460, GSC loc. 100799.
- 12. Inner lateral view of Sb element, x47, ROM 47461, GSC loc. 100799.
- 16. Inner lateral view of M element, x60, ROM 47462, GSC loc. 100799.
- 17. Inner lateral view of Sc element, x28, ROM 47463, GSC loc. 100799.
- 21. Posterior view of Sa element, x80, ROM 47464, GSC loc. 100799.

Figures 13–15. *Elsonella secunda* Youngquist
- 13. Inner lateral view of Sc element, x47, ROM 47465, GSC loc. C-136491.
- 14. Lateral view of M? element, x80, ROM 47466, GSC loc. C-136491.
- 15. Inner lateral view of Pb element, x47, ROM 47467, GSC loc. C-136491.

Figures 18, 19. *Ancyrognathus euglypheus* Stauffer sensu Coen (1973)
- 18, 19. Upper and lower views of Pa element, x40, ROM 47468, GSC loc. C-136491.

Figure 20. *Ancyrognathus euglypheus* Stauffer sensu Coen (1973)?

Upper view of small Pa element, x50, ROM 47469, GSC loc. C-136491.